Solving the Shortage of STEM Personnel in Navy Laboratories: Strategic Plan for Navy Investments in STEM Education Targeted at the "Navy After Next"

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Executive Summary

The Problem

The Navy Laboratory system (NavLabs) has a serious and growing problem replacing its tens of thousands of civilian STEM employees (Science, Technology, Engineering and Math: bachelors, masters, and PhDs). We have been tasked to examine the Navy's STEM educational efforts and how they bear on the shortage of STEM personnel in the Nav-Labs, and develop a Preliminary Strategic Plan to address the problem.

Today's Navy Education and Outreach Programs

The Navy invests heavily in scores of STEM-related educational and outreach (E&O) programs, from K→PostDoc and beyond, in the hope and belief that increasing flow through the "educational pipeline" can help. Most of these programs were conceived and implemented independently of one another. None of them was designed to address this specific problem, and collectively they have failed to alleviate it in any measurable way. No existing program collects data relevant to the fundamental question: "Has this program produced any quantifiable effect on the NavLab STEM problem?" Despite two major studies' recommendations (BEST 2004; Greystones 2007), even the most basic data about the problem have not been collected — how many people will be needed, with what degrees, in what fields, and when? Moreover, increased flow will not benefit the Navy unless some of that increase is captured by the NavLabs, but we have not yet identified any program that requires post-graduation NavLab employment in return for pre-graduation educational support. There is no central locus (e.g., website) for access to all possibilities for Navy educational support, civilian STEM careers at NavLabs, or open NavLab STEM jobs. Recruitment into either STEM education or NavLab STEM careers is either non-existent or done locally by individual NavLabs. A continuation of today's random STEM programs or "business as usual" has not fixed, and will not fix, this problem. Most importantly, it will not address or enable the "Navy After Next."

Preliminary Strategic Plan Generalities

In line with Navy practice of long-term planning for difficult logistical problems, we present here a Preliminary Strategic Plan to address the specific need: "More employee-years of civilian STEM workers at NavLabs." The plan consists of 33+ specific recommendations. Each is straightforward, and leverages aspects of existing programs where possible. Some are recommendations for new programs or approaches. Collectively they form a coherent plan. A more detailed implementation plan can be developed quickly if the Navy adopts the Preliminary Strategic Plan.

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Preliminary Strategic Plan Fundamental Principles

(1) *understand* the problem

(2) *find pressure points* to maximize return on investment (ROI)

(3) *focus* resources and energy on those points (i.e., no peanut-buttering of resources)

(4) *take a 25–50-year view*

Preliminary Strategic Plan Overview

The Preliminary Strategic Plan requires: (1) that the Navy take a 25–50-year view of the problem and devote adequate resources to it; (2) a paradigm shift in how the Navy thinks about/addresses the problem, including how STEM/NavLabs are marketed to students; (3) a focus of effort on the largest sources of potential STEM recruits (today this is women and minorities; in 2040 it will be Hispanics); (4) a campaign to turn STEM careers at NavLabs into prestigious "careers of choice" for those groups; and (5) recognition that for every NavLab STEM PhD there are 17–35 STEM bachelor's and master's degree holders who also need to be replaced, which requires a plan focused strongly on undergraduates.

Specific tasks begin with the collection of basic data on the NavLabs' STEM supply/need, then move through making and maintaining contact with STEM students, developing outcome-specific metrics for all activities, setting up centralized data collection and processing, producing a good central website in concert with a media plan, active mentoring and financial support of STEM college students (all levels, undergrad→PostDoc), required summer employment at a NavLab for all Navy-supported students, collaborations (= leveraging) with other non-Navy programs, focus on pressure-points to maximize return on investment (e.g., K→12 teachers, high school counselors and financial aid advisors), and continually adjusting the program's size and composition to meet evolving future needs. Other specifics address Navy efforts at STEM education in K→12, and at the advanced degree level. [See the **Proposed Action Plan with Recommendations** at the end of this study, and also the 12 supporting appendices.]

Note: Lest the reader become discouraged at the complexity and magnitude of the problem, we provide this bit of comfort: after many months of consideration and evaluation of its intricacies, we believe the problem is solvable. The solution is not easy, quick, or cheap — but is required to ensure the ongoing STEM capabilities of the NavLab system.

Introduction — The Problem and Tasking

This study addresses two major topics: The (1) Navy's present STEM educational efforts and how they might be augmented, even if those efforts initially do not bear directly on the NavLab STEM problem, and (2) development of a de-novo, ground-up strategic plan to directly address the ongoing and worsening difficulty in replacing STEM personnel in the Navy's laboratory system (= the NavLab STEM problem). This entails using to the extent feasible existing efforts, or portions thereof, but also proposing new approaches as needed. [For a briefly detailed list of K→Post Doc education and outreach programs, see App. A: Education and Outreach Programs—Navy and Non-Navy.]

The Specific Problem

As does the U.S. in general, the NavLabs suffer from an increasingly severe shortage of trained replacement civilian personnel in science, technology, engineering, and mathematics (= STEM topics). The Navy's problem is more severe than the nation's because only U.S. citizens can work at NavLabs, and a great many U.S. STEM graduates are foreign nationals. Collectively, NavLabs employ tens of thousands of STEM-trained civilian personnel in dozens of locations across the US. Many are baby-boomers and as that bolus retires, the problem is steadily worsening. The shortage is at all educational levels, although often discussed as if limited to PhDs, but for every NavLab STEM PhD there are 17–35 bachelors- and masters-level STEM employees who also must be replaced — a much larger problem. The problem extends far beyond the NavLabs to supporting industries and the blue-suit Navy itself. We do not consider those extensions here, but we do point out that any increase in flow through the pipeline will go to the nation generally, thus helping meet the Navy's "ancillary" STEM needs.

   –The ***problem addressed*** in an exercise such as this must be carefully delimited:

   A growing shortage of STEM employee-years at NavLabs

–The ***question posed*** is:

   What can the Navy do, through investments in STEM education,
   to improve the supply of STEM employee-years at NavLabs?

–The ***underlying belief*** is that the Navy can (at least in part) solve the shortage by means of existing, modified, and/or new investments in the "STEM educational pipeline" (K→postdoc and beyond).

–The ***expectations*** under which this study was taken are that one can:

   (a) identify existing programs, or aspects of existing programs, which bear
   quantifiably on the NavLab STEM problem

      (b) make more efficient and effective use of those programs through relatively straightforward (hopefully cheap, easy, and quick) modifications

      (c) devise outcome-oriented metrics which will quantitatively document each program's effect on the problem

      (d) given a+b+c, one can better design an overarching long-term strategic plan, the goal of which is specifically to address the NavLab STEM problem

A Need for Long-term Planning

The Navy is very good at long-term planning to develop equipment, strategy, and tactics: doctrine and formal planning exercises are in place for those arenas, wherein the Navy focuses on developing the "Navy After Next." The planning required is complex, and the investments both large and long-term. Time-scales for the personnel and equipment portions of the Navy's needs are similar — a cycle time of 20–50 years for aircraft and ships, and likewise for STEM personnel (K→PhD ~20+ years; K→NavLab career ~50 years).

> *Good equipment, strategy, and tactics cannot be developed or successfully deployed without good people.*

Integrated over time, the Navy's expense in acquiring and maintaining its "people half" quite significantly outweighs that of its "equipment half": the two halves should rate at least equal long-term attention, planning, and investment. We feel the Navy must apply the same integrated, long-term approach to its needs for STEM personnel in the NavLabs. **But at present the Navy has no coherent plan addressing supply and acquisition of adequate STEM personnel**. The Preliminary Strategic Plan proposed here takes a long-term, integrated approach coupled with shorter-term remedies that bear on the NavLab STEM problem.

"Supply" vs. "Acquisition"?

Today the U.S. educational system produces sufficient US citizen STEM people at every educational level to meet the NavLabs' needs. The difficulty is that too few of them opt to work for NavLabs (this can be for many reasons, e.g., not knowing that the labs or careers even exist, or because of the widespread mistaken belief that to work at a NavLab one must be active-duty military). In short, at bottom the problem is not one of "supply" but rather of "acquisition." This means that any Navy-engendered increase in the supply (i.e., more flow through the educational pipeline) will only bear on the NavLab STEM problem **if some portion of that increase is actually captured by the NavLabs**. This in turn suggests strongly that any Navy Strategic Plan must include: (a) specific "capture" or payback considerations, e.g., a requirement for NavLab employment post graduation

as a condition for pre-graduation educational support; and (b) a strong, centralized recruitment effort.

Active High-level Support is Mandatory

The highest levels of the Navy must declare formally that solving the NavLab STEM problem is a high priority, that adequate centralized resources will be devoted to it, that the goal is to focus on aspects of supply and acquisition that will yield the **largest ROI in terms of STEM employee-years at NavLabs**, and that the problem will be addressed in an integrated fashion on the time-scales needed.

The Overall STEM Problem

The national STEM shortage is a longstanding and complex problem that begins early in grade school and continues throughout the pipeline. The Navy funds, participates in, or otherwise supports scores of educational efforts, on scales from local to national. Many of them are aimed at some particular aspect of STEM education. Collectively, in many ways, those efforts address the entire educational process: literally from kindergarten to early-career postdoctoral researchers, even new-faculty and new-professional development. The Navy participates in these programs for many reasons: e.g., patriotism, altruism, public relations, and especially the beliefs (1) that doing so will help increase the flow through the pipeline, <u>and</u> (2) that the Navy will benefit from that increased flow in many ways, one of which (it is hoped) will be more STEM employee-years at NavLabs.

Current Navy STEM Education Efforts

 "Do not confuse activity with progress," said U.S. Army Col. H.R. McMaster, Iraq. The Navy engages in a great deal of activity addressing STEM education, but there has been little or no progress towards a solution of the NavLab STEM personnel shortage. Continuation of today's educational "business as usual" will not fix the problem. For example, we cover in some detail programs in (a) Virginia: The Virginia Demonstration Project; (b) California: "Girl's Day Out" and the "New Professional Program"; and (c) Washington State: NavOps Deep Submergence, SeaPerch, and ROV Challenge. However successful they may be, they all need to be recalibrated to address the Navy STEM problem. [See below in "K→Gray Programs, best practices, and considerations for evaluation." See also Appendices B, C, and D, and supporting Appendices E: Navy Museums, and F: Science and Technology Centers and Pacific Science Center Proposal.]

However, none of those many programs was designed to address this specific problem, and, collectively, they have not solved it. They show no signs of solving it. As expressed by Col. McMasters in a different context, "Business as usual will not fix the problem." Many of them do address (often successfully) aspects of the problem and oth-

ers but there exists no **integrated** plan to address the shortage of STEM at NavLabs. Importantly, (a) the NavLab STEM problem has **not yet been properly quantified** despite two major studies' recommendations (BEST, 2004 and Greystones, 2007), and (b) **no existing program presently collects metrics** that will show whether or not the program has a measurable effect on the number of STEM employee-years at NavLabs. Obviously, if the Navy's efforts actually did increase the flow through the pipeline, the NavLab problem would benefit **only if** some of the increase wound up employed at NavLabs. Yet we have to date found **no program that requires NavLab service in return for educational support**. Additionally, there is no coherent, Navy-wide attempt to recruit STEM employees. Education and recruiting are utterly inseparable, but they are not addressed together. Despite recruitment not being part of our task, we do attempt to include it here because we believe that a strategic plan without it cannot work.

This Project's Fourfold Task

The project calls out two distinct products: recommendations to supplement the Navy's current STEM education efforts (regardless of whether these efforts initially bear directly on the NavLab STEM problem), and a focused Preliminary Strategic Plan to address the NavLab STEM problem head-on

The overall task, however, breaks into four specifics, which leads to the multi-pronged nature of the study and recommendations. All four are interrelated and bear on one another. Although our task here is to develop ideas without regard for their implementation, we nevertheless, in most instances, do consider implementation issues. Development of a **detailed** implementation plan is premature at this time but will be possible in Year 2, given resources and agreement on elements of the Preliminary Strategic Plan to be pursued first.

> ***Task 1:*** *Collect basic data (presently unavailable) on the NavLab STEM problem. Task 1 is critical and must be done immediately: without it no detailed analysis of or planning about the NavLab STEM problem is possible.*

> ***Task 2:*** *For current efforts and programs, develop implementable, quantitative, outcome-based metrics (including tracking), which document two separate things: (a) any effects of programs on the NavLab STEM problem; and (b) other effects on STEM education generally.*

> ***Task 3:*** *Develop de-novo a long-term strategic plan to address the NavLab STEM problem.*

> ***Task 4:*** *Evaluate and implement augmentations to current and additional Navy E&O programs.*

Here we highlight features of Tasks 1–4. [Full discussions in Appendix G: Preliminary Strategic Tasks 1–4.]

Task 1

Collect basic data. Critical data that have never been collected, and which we propose to collect in various ways (in Year 2) include:

>*Quantity:* How many new STEM people will the NavLabs need?

>*Fields:* In what specific fields?

>*Levels:* At what specific educational levels (BS, MS, PhD)?

>*Dates:* By what specific dates?

Task 1(a). Continue interviews to obtain representative QFLD data at various major NavLabs (SPAWAR = completed test case) and UARCs (APL-UW = completed test case).

Task 1(b). Finalize a short email questionnaire (see Appendix G) to go to all NavLab STEM personnel asking for very simple information, to be returned to a (new) central site for collation and analysis. The data will document how much effect various Navy/DoD programs have on the NavLab STEM problem today, and hence bear on any strategic plan's structure and approach.

Task 2

Develop performance metrics for existing and future E&O programs at all levels (K→PostDoc). Those metrics are both process-oriented and outcome-oriented, and involve tracking all participants, including rejected applicants. Use "soft" and "hard" engagement techniques: require G9→G12 programs (and especially those students who compete for various awards) to provide a contact address (email, U.S. mail) for both participants and their parents; and work with high-school staff to identify particularly good STEM-oriented high-school juniors and seniors for summertime research experiences at NavLabs.

Task 3

Design a strategic plan aimed at the NavLab STEM problem. The plan will require a significant paradigm shift in Navy thinking about the problem, resulting in new communications and other actions; extension of the plan across several decades; and pre-adaptation of Navy STEM strategies to inevitable long-term demographic changes in the nation. Two core changes must become explicit high-level Navy policy: (a) emphasis on women

and minorities; and (b) emphasis on the humanist aspects of STEM work. A detailed implementation plan can be developed for the final plan once the Navy adopts the Preliminary Strategic Plan.

Task 4

Evaluate and augment current K➔Gray and additional new programs with tracking and payback mechanisms to address the STEM problem.

The four tasks are very different in terms of focus and time-scale, but are and must be closely linked to produce an integrated solution to the problem, and we present ways to integrate them. Those parts of current Navy investments that actually bear upon the NavLab problem must be identified and used both now and in any strategic plan. **Importantly, even the lack of the most basic data on the NavLab STEM problem (Task 1) does not preclude initial steps in implementing a long-term strategic plan**. Initial actions can be taken quickly to, for example, collect data specific to the STEM shortage in the NavLabs, which will be required (in some form) by any final strategic plan. [See App. G: Strategic Tasks 1–4 for full discussion including implementation plans and rationale.]

From the problem and tasking definitions flow considerations for what to do and how to carry out resulting required actions. The remainder of this report deals with:

- *Thinking in new ways*
- *Examining E&O efforts*
- *Suggesting efficient augmentations that can make a difference*
- *Identifying best practices*
- *Communicating changes in direction*
- *Revitalizing the Navy's web presence as a tool for increasing STEM professionals at NavLabs*
- *Maximizing use of UARCs*

Followed by:

- *Actions discussion*
- *Action plan with rough timeline and recommendations*
- *Appendices A–L*
- *Important literature*

How Should the Navy Think About the K→Gray STEM Problem?

The Current State of Navy E&O Programs

The Navy must think about (i.e., "see") its E&O efforts for what they are. Unfortunately, as far as we can tell, those E&O programs, particularly K→12, are conducted largely in isolation from the Navy's overt consciousness of, and efforts to solve, the overall STEM problem. Local Navy and non-Navy organizations are responding (often impressively so) to meet their local community's needs and education/outreach goals (e.g., SPAWAR Pacific must participate in the San Diego Science Festival). But there is no central approach, guidance, support or evaluation of such efforts, however laudable. Current efforts, particularly K→12, are local, shotgun efforts that throw time and energy (mostly volunteer) and funds (largely local, and therefore de minimis) at the STEM problem without a coordinated commitment from the Navy.

Lack of a Payback Requirement

As a result of the diffuseness of naval E&O programs nationwide, there is an appalling lack of payback to the Navy for its investments. Students who participate in Navy-sponsored projects or programs, from short-term local events to extensive Navy college-education financial aid, are not required to repay the Navy for its investment, e.g., via post-graduation employment at a NavLab. Students may not even know the Navy is a participant or has a vested interest in their support, let alone why the Navy might be hosting a half-day event for, say, middle school students. In many cases there is no connection from student participants to parents, teachers, and school counselors, yet there easily could and should be. All Navy E&O programs should carry honors and advantages, and at every college-degree level should entail a commitment to pay back – preferably via NavLab employment – for the support provided.

An integrated strategic plan that addresses K→Gray and contains mandatory, built-in payback mechanisms will mitigate this problem.

Paradigm Shift

A paradigm shift is required to solve the NavLab STEM problem. The shift has three stages: (1) Thinking; (2) Communication; and (3) Action. We first discuss the shift in thinking from which will flow all action and communication with the public. Instituting this shift in thinking is critical for establishing a workable, integrated, effective strategic plan.

Any strategic investment plan by the Navy to increase both the supply and acquisition of STEM personnel must specifically and explicitly address today's largest untapped poten-

tial resources – namely women and minorities – and also prepare the Navy for when the largest resource base changes to Hispanics ~25–30 years hence. The investment must be prolonged and consistent because the time-scales are years to decades.

> *The Navy must make NavLab STEM employment into a high-visibility,*
> *highly desirable, well-known career option of choice for these groups.*

Doing this will require a shift in how the Navy views and markets STEM education and NavLab STEM careers, i.e., changes in media: where, when, and to whom. We propose a carefully crafted radical shift from traditional emphasis on attracting candidates via the "Four Bs" (Build-Big-Boom-Bang), to what we call a 'humanist' approach. This shift is imperative: the Four Bs simply do not appeal to most women, and women are the largest available pool of potential STEM recruits. A "humanist" approach de-emphasizes the four Bs and promotes the reality that most STEM work at NavLabs is, in fact, directed at problems that have very strong positive implications for human well-being as opposed to overtly centered on military concerns like weaponry. Examples abound, such as ultrasonics (largely developed by the Navy), which are certainly used in various military applications, but primarily and most widely useful in medicine, industry, and science.

The humanist approach has proven highly effective in recruiting and retaining women (and also men) into UG (undergraduate) STEM education, and the Navy should help develop, promote and disseminate the techniques developed by primarily undergraduate institutions (PUIs). Gonzaga University is a PUI in Spokane. WA with a few masters programs (mostly non-STEM) and no PhD programs, but it has an extensive and well-respected UG STEM program. Several years ago they began emphasizing humanist approaches to recruiting students, particularly women, into STEM. Gonzaga changed how it structures STEM curricula (particularly engineering) to emphasize humanist concerns. They have succeeded spectacularly well: more women wish to get in than there are spaces available, and none drop out. Gonzaga has a 100% completion (BS) rate so far with N~150. An explicit Year-2 goal herein should be documenting and understanding the important transportable elements of Gonzaga's program. The nation has an extensive network of such PUIs where a Gonzaga-style program, once fully developed, could be implemented.

The Gonzaga program involves intensive faculty and student mentoring of new students, restructuring of the approach within classes to emphasize humanist concerns, and two full summers of on-the-ground work using their training to solve human problems in Africa. Students know from day one of their freshman year that all summer between freshman and sophomore years they will be working in the real world, and that they will actually be using the classroom knowledge. As a result they study hard. Second-time field students (sophomore–junior year summertime) provide intensive peer mentoring to first-year students on the ground in Africa, and also during freshman-year classes. Classes themselves center on hands-on solving of human problems, in teamwork with non-STEM students at

other nearby PUIs. (Note: Another "long-view" advantage of targeting women is that many will become the mothers of possible future STEM workers.)

Looking forward, the techniques and partnerships developed by the Navy in the course of learning to promote STEM education and careers amongst women and minorities will enable the Navy to effectively address the next great change in the human resource base, namely, Hispanics, which presently has the same sorts of STEM recruitment problems as do women, and in ~25 years will be the majority of citizenry in the U.S. Working today with women and minorities will enable the Navy to be pre-positioned for that demographic change.

> *These changes: (a) focusing on women and minorities through emphasizing humanist aspects of STEM work, and (b) pre-positioning the Navy to deal with demographic change, must become explicit Navy policy.*

Concentrate on Pressure Points, Especially Undergraduates

The critical parts of the STEM supply and acquisition is undergraduates (within which category we include both BS and MS degrees), hence the Navy's STEM efforts should concentrate here. They are, in fact, the major problem at NavLabs. SPAWAR Pacific is a specific example: it has 17–35 BS and MS degree holders per PhD (and every advanced degree holder also goes through the BS stage). In December 2008 SPAWAR had ~1800 BS, ~750 MS, and ~143 PhD STEM employees. Over 50% of SPAWAR's PhDs are full-time administrators, which suggests a simple solution to any genuine documentable shortage of PhDs.

Further, the Navy should concentrate on PUIs because: (a) some of them already have a good handle on the humanist approach to marketing STEM to women and are succeeding; and (b) PUIs' main product is high-quality BS degree-earners. They know how to produce that product better than do many high-powered "RO-1" universities, which often view their own function primarily as producers of a small number of very high quality PhDs. In short, the PUIs often do a better job of UG education than do the bigger schools because UGs are their sole area of concentration.

All of which is not to say that K→12 and PhD-level efforts do not also have their place in the plan; they do and will be discussed below, but the area of major concentration for a strategic plan must be on undergraduates.

Where Does the Paradigm Shift in Thinking Lead?

Once the Navy shifts to emphasizing women, minorities, PUIs, and UGs, the task becomes capturing these STEM graduates for the NavLabs. Payback is a significant capture technique.

Requiring payback

In short, recipients of Navy college-education funding must be required to repay the Navy via specific periods of work (as well-paid civil-service employees) at NavLabs. We are suggesting a more overt plan than anything we have yet encountered amongst Navy programs. Payback mechanisms should take various forms commensurate with what was given and appropriate to the age of recipients. Getting funding for college education, for example, requires a stronger payback than would receiving non-cash opportunities. For K→10 students participating in Navy-sponsored activities, "payback" might simply be granting permission for the Navy to follow up with information on additional opportunities and career choices to the students and parents.

> *Specifically, for Navy educational support in STEM at the university level,*
> *the Navy must insist on a return in the form of employment at a NavLab.*

This concept is nothing new to the Navy (e.g., ROTC, Navy "1800" career-officer program, and the like). Nor is it new elsewhere in the nation (e.g., various forms of traineeships across the federal government). Navy STEM educational support should be in the form of a convertible loan, repayable either via money (with accrued interest) or, preferably, employment at a NavLab. Extend this concept to include graduate student support whether direct or via Navy-funded research grants to academic PIs. (This type of support should not replace the traditional research proposal that includes an "un-named graduate student" but should be available as an option to the student, perhaps competitively.) This opportunity should include a student option as to where to work (i.e., which NavLab), debt forgiveness on an XX%-per-job-year basis, and other incentives, e.g., further forgiveness for active mentoring of UG Navy-funded STEM students or for helping with local K→12 efforts, or for training counselors and teachers, etc.

> *The Navy has so much to offer it should not*
> *be shy about blowing its own horn.*

What other employer, particularly in today's job market, can offer educational support plus career-long employment with numerous advancement opportunities, not to mention benefits? The Navy would be wise to put **payback mechanisms** in place **now** because today's advantageous ratio of applicants per Navy job won't last forever. Developing a series of letters, one civilian recruitment brochure, and one educational opportunities brochure are not arduous tasks; they could and should be accomplished within six months. All Navy (and DoD) E&O programs should be augmented thusly via a top-down, funded mandate. [See App. H: Payback Mechanisms, for probable scenarios that detail recipient obligations.]

K→Gray Programs, "Best Practices," Considerations for Evaluation

Some fine E&O programs have emerged organically, and can serve as sterling examples of Navy people and facilities committed to STEM education. In some cases (e.g., Keyport, WA) they have risen because the local NavLab and shipyard found that STEM professionals hired in from outside frequently left in short order, often due to unfamiliarity with local conditions and lifestyles. Hence Keyport found it had to "grow its own" STEM professionals locally, thus producing people who know the area a-priori and will stay. Keyport's programs might well serve as models for other such regions.

Navy efforts in VA, CA, and WA (1–3 below) include successful programs that span most educational levels and emphasize Navy-relevant disciplines. Those facts, coupled with the programs' growth over time, would indicate these programs should be continued. However, they need to be evaluated (using objective data) in relation to other programs to understand which programs or what aspects of them should be continued, and/or expanded to other locales, so as to make certain the Navy is expending effort and funds wisely and effectively. Each program has unique attributes and implementation strategies worth examination (and perhaps promulgation). Here we touch briefly on three exemplary efforts, leaving full discussions to the appendices. [App. B: Virginia Demonstration Project; App. C: SPAWAR Systems Center Pacific (SSCPac) E&O Programs 2007–09; App. D: NavOps Deep Submergence, SeaPerch, and ROV Challenge with Funding Proposal; supporting Appendices: E: Navy Museums, and F: Science and Technology Centers and Pacific Science Center Proposal.]

1) Middle School: The Virginia Demonstration Project

This is an ONR-funded program launched in 2004 as part of N-STAR (Naval Research – Science and Technology for America's Readiness). The Virginia Demonstration Project (VDP) was initiated to show a diversity of pre-teens and teens — the critical age group for establishing a life-long interest in STEM — that math, science, and engineering are fascinating, fun, and socially relevant. VDP emphasizes problem-based learning. Students use robots, computers, Powerpoint presentations and movies they wrote, narrated, and produced to explain their creative solutions to save lives, clean oil spills, and clear mines from land and water. A study in 2007 found that "[VDP] students have an increased interest in pursuing STEM careers and that they exhibit increased knowledge in and ability to use science and mathematics."

> *" 'N-STAR definitely changed my mind,' [said] Kaitlin McDonough, an H.H. Poole Middle school seventh grader after giving a brief about how to clean up an oil spill and protect coral reefs and marine life. 'Before our project, I saw math as just numbers. Now, it's a whole different subject*

that I think everyone should have a chance to learn. Engineering is for everyone because everyone can do it'."

By the end of the 2006–2007 school year, 3042 students, 86 teachers, and 48 scientists and engineers had participated in VDP. Fifty school counselors had participated in its counselor-education programs. Ten different sets of professional development training activities were provided to professional co-teaching teams. Along the way, the VDP team learned that additional dedicated personnel are needed to support efficient and reliable data collection.

VDP's ultimate goal is to establish educational outreach programs at other Navy R&D centers. The initiative could eventually expand beyond the Navy and evolve into a national demonstration project encompassing all DoD laboratories in a sustained effort to hook more kids on math and science at an earlier age. The hope (expectation?) is, of course, that students so affected will continue through STEM education and into STEM careers. Presumably, the number of students earning university degrees in STEM will increase. That in turn might help with the NavLabs STEM problem – but if and only if some of the increase is captured.

VDP's emphasis on all students and four disciplines, including English and Art (as opposed to Keyport, WA's programs, #3 below), is unique and significant. Parents, counselors, and a wide spectrum of teachers can get involved. The entire school district knows that it is part of a national movement to change education and produce more scientists and engineers.

While VDP's goals and core elements for evaluation (detailed in App. C) are laudable, we do not think they are as aggressive as is needed to address the STEM problem. Again, the programs lack tracking and payback mechanisms. In fact, as VDP researchers admit, "… the long-term connection between participation in the VDP and academic achievement and future employment decisions is less than clear at this time." One cannot fault them for that, but the Navy should encourage VDP management to ask more of their program. On the other hand, without some sort of centralized guidance and support (presently nonexistent), it is very difficult – actually counterproductive – to criticize such local efforts too strongly, or even to make suggestions for changes.

We heartily agree that expansion of VDP-like programs into Navy R&D centers throughout the country is a fine idea, but with one suggestion: up the ante and tell students, parents, teachers, and counselors that the Navy wants these students to consider civilian STEM careers at the NavLabs, and then give them plenty of information about such careers. [See Bibliography and App. B: The Virginia Demonstration Project for details.]

2) Middle School and New College Graduates: Girl's Day Out and the New Professional Program

The Space and Naval Warfare Systems Command (SPAWAR) Systems Center Pacific (SSCPac), San Diego does a phenomenal job of E&O: two programs detailed here are representative of over 22 separate local efforts, which *in toto* are an astonishing testimony to their commitment to STEM education. A brief discussion follows:

Girl's Day Out (GDO). SSCPac initially focused on high school but now address mainly middle school because there are too few high school women interested in STEM. (Note that the STEM problem has become internally self-referential!!!) Further, this is only SSCPac's second year with funding (they now receive $250K annually from NDEP).

SSCPac hosts GDO that began November 2008, and has since included five separate events. GDO is a very popular science and engineering fair for middle-school girls at the University of California San Diego and San Diego State University. The girls explore STEM subjects while on a college campus. The program began with 35 girls and increased with each GDO event to 45, 60, and 70 from schools all over San Diego (plus parents and external volunteers, mostly college-age women). GDO's rapid growth suggests it should be studied for possible replication elsewhere.

SSCPac's New Professional (NP) Program began in the early 1960s, and is the primary means to introduce newly-hired science and engineering graduates to SSCPac's workforce. This is specifically an effort to bridge the gap between academic training and professional work. SSCPac typically hires 75–100 talented, entry-level STEM professionals per year into the six-month rotational NP program, which is part of a two-year developmental training program that includes both formal and on-the-job training. The NP Program is mature, successful, and should be examined for its ability to attract STEM graduates and its retention success among new hires, and then either augmented or duplicated at other NavLabs. [See App. C: SPAWAR Systems Center Pacific (SSCPac) E&O Programs 2007–09, for further details of these and 20 additional SSCPac programs, plus our recommendations.]

3) K→12 and Beyond

NavOps Deep Submergence, SeaPerch, and ROV Challenge. Since 1999, the Naval Undersea Museum Foundation (NUMF) has worked to improve science curricula and to instruct K→12 teachers in STEM topics. Their programs have touched ~50,000 students in 14 WA state school districts. These interrelated programs collectively address the entire spectrum of K→12 and extend into community colleges and the University of Washington. We feature the three core programs here. We also note that, once again, no data are collected that bear on the NavLab problem: of course, these efforts were not designed

to address that problem, hence this observation is not a criticism, rather it merely shows the opportunity.

NavOps Deep Submergence ™

This NUMF-developed curriculum targets middle school, and teaches navigation skills, ocean ecology, physical and chemical oceanography, physics of sound, and the EM spectrum. Students merge classroom studies with submersible and surface technologies to gather data and solve environmental problems within a virtual/simulated "sandbox."

SeaPerch

"Integrating Ocean Exploration into the Classroom" (G7→10) is a five-to-six week ROV-building experience where students are mentored as they are introduced to underwater robotics. Students build propulsion systems, develop controllers, and investigate weight, buoyancy, and trim.

ROV Challenge Program

(G11→12): Students design and construct ROVs as part of marine science and advanced placement physics classes. Students then launch their ROVs in a pool and address various underwater tasks simulating real-world technical work on a mooring.

Leveraging and cooperation

These programs highlight the leveraging of local resources that is possible. Active program collaborators include: Underwater Admiralty Sciences, Inc., Lockheed-Martin, Naval Undersea Warfare Center Division Keyport, Raytheon, Northup-Grumman, British Aerospace Engineering, Sailors from the Trident Submarine base at Bangor, Puget Sound Naval Shipyard, divers from the USS *Emory S. Land*, and the Naval Undersea Museum Foundation. Although these three programs have about doubled in size annually, growth has been hampered by a lack of administrative support personnel, software upgrades, documentation of newly developed curricula, and support materials.

We see no drawbacks to Keyport's programs and, in fact, believe they should be leveraged and emulated wherever Navy museum foundations are co-located with warfare centers and/or other Navy organizations. [App. G: Navy Museums, lists possibilities.] The museums are key for two reasons: (1) Museum foundations have in place the critical administrative coordinator(s) to advance programs in their communities; and (2) as 501(c)3 foundations they can solicit support from schools, business, and industry, in the form of cash and STEM volunteers. [See App. D: NavOps Deep Submergence, SeaPerch, and ROV Challenge with Funding Proposal for further program particulars, photos, and detailed funding proposal.]

4) Partnering with NSF-funded STCs on K→9

"SeaPerch Afterschool" and "SeaPerch Summer Camp." The Navy would be wise to consider partnering with the 300 NSF-funded Science and Technology Centers (STCs). All STCs have a mandate to undertake efforts at STEM in K→12: expand what is available in formal classroom settings via hands-on, self-directed, visual, and auditory activities that engage students in memorable, fun experiences with science. In particular, the Navy could augment NSF-funded K→6 programs within various STC efforts, especially at UARC campuses. Further, a key component of STC partnerships that have Navy-relevant content is the ability to reach parents outside of a traditional educational environment. Few other venues offer the Navy such a rich source of free PR, or so much potential for high leverage.

More leveraging: expansion of Keyport's program. As a follow-on to Keyport's activities the Pacific Science Center (PSC: Seattle, WA) proposes to extend the SeaPerch program through "SeaPerch After School" and "SeaPerch Summer Camp," two new programs designed to reach G6→9 students. The programs also meet our suggested paradigm shift in thinking. PSC has a history of designing and conducting such programs and of partnering with STCs, and could serve as developer of a template for SeaPerch-like partnership programs in similar venues, i.e., warfare centers, museums, etc. [See App. F: Science and Technology Centers and Pacific Science Center Proposal for program details.]

5) K→Gray

Other "best practices" examples of successful Navy programs are listed immediately below; this list is not comprehensive but does represent all educational levels. All seem to merit continuation. **However, without outcome-oriented metrics and supporting data we cannot know which are most effective or in what ways**. We need a detailed examination of all E&O programs, including funding. In Year 2 we plan such an examination, which will yield a data matrix showing at a glance gaps, duplications, funding, sponsors, etc. It will help in decision-making, e.g., where to increase funding, and which (if any) least effective programs might be eliminated. This matrix should be kept current.

Example "best practices" E&O programs:

- K–12–UG, *PEP*, Pre Engineering Partnerships, summer research institute, opportunities for college engineering students helping K-12, NDEP

- G10–12, *SLM*, STEM Learning Modules, NDEP

- G10–12, *SEAP*, Science Engineering Apprenticeship Program, ONR, ASEE

- G10–12, *NSAP*, Naval Science Awards Program, recognition, incentives, scholarships for participants in regional and state science fairs, administered by American Academies, ONR Education Outreach Program, Dr. Anthony Junior, Program Manager, Sponsor: ASS, Academy of Applied Science

- G10–12, *ISEF*, International Science and Engineering Fair w/ NSAP, ONR, Marine Corps

- G10–12, *JSHS*, Junior Science and Humanities Symposium, universities and DoD: Army, Navy, Air Force

- UG, *CISD*, Center for Innovative Ship Design in conjunction w/NREIP, NSWC Carderock

- UG, *SCEP*, Student Career Experience Program, SCCSD

- UG, *STEP*, Student Temporary Employment Program, SCCSD

- UG–PhD, *SMART*, Science Math and Research for Transformation, NDEP

- UG–PhD, *HBCU*, Historically Black Colleges and Universities, NAFEO

- UG–PhD, *NREIP*, Naval Research Enterprise Internship Program, ASEE

- MS–PhD, *NDSEG*, National Defense Science and Engineering Graduate fellowship, ASEE

- MS–PhD, *NSSEFF*, National Security Science and Engineering Faculty Fellowship, NDEP and DDR&E

Thoughts on Navy efforts in K→12 STEM education, the "pipeline" and the NavLab STEM problem

K→12 must be treated differently from higher educational levels. The "pipeline" problems at K→12 are very difficult to address. It is widely understood that students need to be drawn towards STEM education by G6 if they are to make a purposeful run at high-level STEM education. An expensive, extensive, nation-wide effort (largely through miscellaneous E&O programs) to increase K→12 student involvement and interest in STEM has lasted decades, with only small success – the Navy cannot hope to solve this problem via Navy efforts alone. That said, it certainly does not suggest that the Navy should not be involved in K→12. There are many good reasons for Navy K→12 involvement – altruism, PR, enthusiasm at the local NavLab level, and the possibility of undocumentable but positive effects on actual problems. It does seem exceedingly unlikely we will be able

to develop metrics that relate the basic NavLab STEM problem to any specific K→12 efforts by the Navy, although metrics internal to K→12 must be developed and used (e.g., number of teachers, students, parents, counselors contacted; number of repeat contacts with individual students; etc.). Undoubtedly, if executed properly (i.e., with Navy visibility as to program support, and both student and parental knowledge of STEM educational and career possibilities), over time, a well-designed suite of Navy K→12 programs (no matter which agencies fund them) should in the future help increase STEM trainees available to NavLabs. What follows is an argument and outline to begin that discussion, which necessarily goes beyond just K→12.

How might the Navy address the entire K→Gray STEM problem?

In effect, the Navy already addresses K→Gray (albeit in a haphazard and non-uniform manner) by working both within the Navy and in conjunction with many and varied national non-Navy STEM efforts. *A major (i.e., complete) lack is: (1) a focus on STEM recruiting within E&O programs that (2) have built-in tracking and payback mechanisms*.

Because we know that **someone** needs to reach students by G6, and the national effort to date has had little success, it is clearly in the Navy's best interests not to limit its E&O efforts only to colleges and beyond. This is especially obvious given our claim here that the Navy must make a paradigm shift to taking a systems approach and long-term view of such problems. Because return on investment is especially hard to measure in K→12 efforts, we need to focus Navy efforts on innovative approaches that have the most potential to affect the STEM problem in the early grades. Many innovative local NavLab E&O efforts already concentrate strongly on this area: locally-proven good ideas abound and should be studied and exported whenever feasible.

We suggest a Navy K→Gray STEM Plan (KGSP). [Details in App. I: K→Gray STEM Plan.] KGSP involves developing various partnerships to gain Navy access to contact information for high-scoring K→12 students in STEM disciplines on national education tests, and to use that access to provide information to the students and their parents about Navy STEM careers and Navy STEM financial aid for college studies. This approach can also be bolstered through partnerships with other agencies such as NSF. The KGSP delineates various approaches appropriate to K→6, G7→9, and G10→12 with regard to acquiring contact information from national test results within a Navy Strategic Plan to increase STEM worker-years in NavLabs. KGSP then branches into approaches for UG, PhD, PostDoc, Faculty, and Grays, all of which dovetail with the concept of mandatory payback mechanisms.

6) Communication Considerations: the Navy Needs a Humanist STEM Media Plan

As the Navy makes its paradigm shift in **thinking** it must undertake numerous **actions**. One action that is critical to making the strategic plan work is **communication** of the Navy's direction, resources, and needs to the public, and most especially to the target audiences (potential STEM students and their parents). We propose the Navy do so by developing and launching a national media campaign, which we call the HSMP (Humanist STEM Media Plan).

The Navy's communication needs are well-understood and manageable if faced head-on with adequate resources and a good plan. BBMG's study "Because Dreams Need Doing**"** (2007) concluded that to change negative misconceptions about engineers one needed "… a sustained engineering-community-wide communications campaign." The Navy needs a similar campaign re: NavLab STEM careers. During Year 1 of this study, (now concluding), we have repeatedly encountered multiple, fundamental deleterious misconceptions about STEM careers at NavLabs. Examples include: (a) "the Navy only works on weapons systems"; (b) "one must be active-duty Navy to work at a NavLab"; and (c) "What the heck is a Navy Laboratory, anyhow?" Even amongst present NavLab STEM employees, there is near-unanimity that they, themselves, found out about NavLab STEM career possibilities only through blind chance and word of mouth. ***This is no longer acceptable.***

Regardless of the details of misconceptions, they contribute, perhaps strongly, to the bottom line: too few STEM personnel end up at NavLabs. To make progress, a concerted effort is needed that addresses the misconceptions in the most positive way possible.

Any (and all) current, augmented, or future E&O programs will fail
to rectify the STEM problem without a unified, coordinated effort
to address the target audiences.

The need for HMSP comes from three considerations: the (1) widespread need for, and complex problem of, attracting more scientists and engineers into NavLabs; (2) the nature of the audience the Navy needs to attract; and (3) current lack of a unified message across the naval research enterprise. The HSMP media campaign should be ubiquitous and waged through print (e.g., minimally two brochures, frequently updated: one for recruitment into careers, another for E&O program and funding opportunities), websites, promotional items, video, TV, radio, technical society meetings … anywhere potential STEM-qualified personnel and even the general public, i.e., parents of K→12, are likely to bump into it.

The message must be coherent and consistent. An uncoordinated message will lose STEM candidates because the information they need will be confused or unavailable.

Who has time to figure out how to get hired, or how to take advantage of an education program? And why bother with an organization that cannot communicate what it wants and needs – presumably because the organization itself does not know? Potential employees will give up and go elsewhere to other organizations that clearly want and are ready for them. ***Coordinating what is presented in print, promotions, video, TV, radio, and the web benefits everyone, particularly the Navy, as it costs far less to say the same thing everywhere. What's more, doing so makes the message memorable.*** [For media plan implementation details see App. J: Humanist STEM Media Plan (HSMP).]

The faces of the campaign should be those of ***diverse, young STEM professionals*** at work helping improve lives and the planet. These images must immediately become associated with the Navy in the way the goodness of milk is associated with a milk mustache in the "Got Milk?" advertising campaign. The message should be coherent, short, coordinated, and repeated across all media, and should contain these elements (but obviously not in sentences quite like these):

"STEM graduates, NavLabs want you and need you. We're ready for you. We've been expecting you. We're glad you're here. You'll have fun contributing to society in a secure, well-paying and highly-respected career."

An overarching media plan can serve as the glue, if you will, for the Navy's Strategic Plan. Ongoing depictions of NavLab STEM careerists making humanist contributions within STEM disciplines will continually reinforce the civilian Navy's new image. One subtle advantage to waging such a campaign is that once it is developed and launched, HSMP will help maintain the Navy's focus on the problem's goal.

7) Overhaul Navy Websites

Prior to launch of HSMP, but simultaneously with its development, there must be an overhaul of Navy websites. Most of the Navy's potential web audience, including those interested in STEM careers, is young, anywhere from grades 6➔PostDoc (~ ages 11–32). They are brilliantly and addictively web-savvy. **Most current NavLab websites display little or no ability or intent to appeal to such audiences.** All potential candidates are accustomed to going to the web for an initial look-see on any topic. The immediate availability of search engines and their swift retrieval of information make this behavior universal. Their procedure is to amass as much information as possible, over the widest range of sites, as quickly as possible. Any website, therefore, has between seconds and a maximum of one minute to capture a user's attention. The target audience(s) are entirely up-to-date and not interested in exploring sites that are inefficient or out-of-date in appearance, function, or content. Thus, home pages must:

1. Ooze a 21st Century look/feel and include an immediate "in your face" indication of all that lies within

2. Quickly state the needs and benefits of the organization

3. Clearly and efficiently outline the advantages to the website user for further exploration

How to be effective

Any site must show at once, without searching, whether the Navy needs STEM people; what jobs are available in what fields and where; whether E&O is happening (and if so what and where and when); and so forth. All this should be instantly visible on first-contact.

> *The Navy cannot neglect to fix the problems associated with their websites. The web is ubiquitous and widely used – the web is the public's view of the Navy, and especially the view received by STEM candidates. The sooner fixed the better.*

What we found vs. what we expected

We originally considered our examination of Navy-related and K➔PostDoc E&O programs (done by looking at their websites in detail; examples in App. K) as an isolated activity, which would identify all such entities and programs. We expected that we would then see holes and duplications in programs, make recommendations for consolidation and expansion of those most in need, and thereby have a pretty good handle on the Navy's situation. This has not proven to be the case. Further, it quickly became apparent how intricately connected 'recruitment/careers/jobs' are to education, and that they need to be shown and thought of as connected.

We found that very few sites address the NavLab STEM problem under study here. Often, mention of E&O programs on Navy websites is tucked away in hard-to-find locations; not all E&O programs are featured on the websites; not all websites have E&O pages; and there is no across-site common language about the programs. Cross-referencing from one site (or program) to any others is essentially nonexistent. ***Furthermore, these sites give a strong impression that they are aiming at a target audience that is internal to the site-sponsor, rather than at the outside world.*** For example, some sites' home pages open with a photograph of the local commanding officer (with link to his/her CV), and little or no information about jobs, careers, or educational activities. Visitors looking for work do not care who is in charge, and will leave within seconds if they cannot find relevant information. ***And, they won't come back.***

Navy websites have other problems as well. They reflect an earlier "WWW-era" when the goal was merely to have a web presence. Even today, most Navy-site content is largely print media loaded onto the web, including PowerPoint presentations (offered, necessarily, without the benefit of the speaker who presented them in the first place).

Posted information is frequently years out of date (and openly dated that way). ***Mostly, today's websites (with rare exceptions) represent the Navy talking to itself with little, if any, awareness of an external audience.*** Notable exceptions to these claims are presented below in "Examination of Navy Websites, including Best Practices."

We recommend fixing the web problem immediately, through a concerted effort in Year 2. – e.g., while designing, but before launching, any national media campaign. We so recommend for two important reasons: (1) a national HSMP will naturally create more web traffic and the message/look/feel has to be identical for it to be convincing and have the potential to change perceptions and behaviors; and (2) the web problem is somewhat less expensive and more easily remedied. Once the HSMP profiles are launched on the web they can then be available for more extensive use in other national media. [See App. J: Humanist STEM Media Plan.]

Web ideas that will NOT work

1. For some time, we hoped, as a cost-saving measure, that we could recommend placing a jobs or education button on all existing sites and thereby solve the problem. This would be an improvement, but, without a complete overhaul, the widespread problem of outmoded, navigationally-challenged, and ineffective websites would remain: *a single good button on several hundred bad sites is NOT a solution.*

2. We also thought originally that the best way to institute website revision would be masters and decision makers from each NavLab to be shown (by new core staff) how to implement these changes. However, this seems unnecessarily expensive and logistically cumbersome.

The best plan for Navy websites

Have APL-UW develop a single, central, national core website covering civilian STEM careers, jobs, and educational support. This site must be up-to-date; designed to appeal to the main demographic target (i.e., highly web-sophisticated teens and college students); be searchable by many parameters; be continually-updated and easily updateable. ***Above all it must provide students (at all educational levels) and parents with instant, easy access to information on NavLab STEM careers, to all existing specific job openings in the NavLab system nationwide, and to Navy STEM educational support at all levels.*** All local and nationwide positions will be posted here. All local NavLab websites will also post local positions and will link to this central jobs/careers site so as to get nationwide coverage. This mild form of duplication is necessary to reach users through any of the various avenues they might take to find job/career information.

This central site must enable:

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1. the searcher to make direct contact quickly with representative NavLab careerists (which means a live human on the line) so as to acquire detailed information

2. the searcher to make direct contact with hiring personnel for any existing job opening

3. a student to apply, with a single electronic submission, for all forms of Navy financial support for STEM education. This central site must also provide for electronic submission of resumes and applications for specific positions. The site requires dedicated, knowledgeable, well-trained, web-savvy personnel who can also help with other web-based efforts.

APL-UW should develop a website template for NavLab websites that unifies design, language, and core content whilst encouraging local flexibility. This template will have a prominent button that seamlessly links to the central, look-alike, civilian-Navy jobs and careers website. All available local employment positions will be clearly featured while simultaneously the central jobs/career site will be advertising the wealth of opportunities offered by NavLabs throughout the US.

Examination of Navy websites seeking to identify "best practices"

Originally, we anticipated producing our detailed, evaluative "report cards" on all Navy websites but the task proved overly repetitive because so many looked and behaved similarly. Rather, we have detailed typical problems and identified elements of "best practices" across a wide selection of sites. Then in Year 2 we can develop solutions (based on best practices) that might be offered (or mandated) to Navy websites to help them better attract STEM professionals into the civilian Navy workforce. See App. K: Website and Activity Report Cards, which includes report cards for:

1. NAVSEA
2. *NAVAIR
3–6. NSWC: *Carderock, Dahlgren, Panama City, Port Hueneme
7. NUWC, Keyport
8–12. SPAWAR: Pacific San Diego; Atlantic: Charleston, New Orleans, Norfolk, SSFA
13. UARC: *APL-JHU
14. NDSEG

Notes:

a. Printouts of web pages are available upon request, containing comments that support the evaluations presented in the report cards.

b. *Example websites with notable "best practices" elements include: NSWC, Carderock, NAVAIR, and APL-JHU, but that does not mean these sites do not also need improvements. They do. Nor does it mean there are not other Navy websites that might be listed here with elements of "best practices." There are.

c. Although the National Defense Education Program (NDEP) is not part of Navy websites per se, some of their programs have partnerships with the Navy. **NDEP's website is nothing short of splendid and takes an approach similar to what we propose for HMSP (i.e., featuring young STEM professionals).**

8) Maximize Use of UARCs

The Navy must expand and nurture its already close ties with research academia (e.g., the University Applied Research Centers or UARCs) and the academic institutions and processes that produce STEM bachelor, master, and PhD degree earners.

UARCs are a unique educational and research asset, particularly at the advanced-degree levels, but also for UGs. UARCs are particularly good at: (1) divining long-term future trends in science and technology, hence future Navy needs for advanced-degree STEM leadership personnel – and then producing those personnel, usually in advance of need; (2) conducting Navy-relevant research and development; and (3) spinning off STEM graduates into non-NavLab but Navy-critical positions in industry and academia. UARCs have multiple roles in supplying overall Navy needs for STEM-trained people (including resupplying the UARCs themselves).

UARCs are in a position to independently evaluate and respond to Navy needs for advanced-level STEM personnel. *UARCs should be given the freedom and dedicated resources to support UGs, graduate students and PostDocs of their choice, selecting students and projects on what the UARCs independently think are Navy-relevant.* Each UARC should be given the equivalent of 'block funding' to support (say) five years of PostDoc efforts annually, plus resources to support some specified number of UG years, specifically on Navy-relevant work, with an eye to recruiting recipients into further involvement at NavLabs and thence into STEM careers.

UARC faculty and graduate students should be actively recruited as technical experts to participate in various items in this Preliminary Strategic Plan: on-campus mentoring, developing K→12 educational materials, identifying and recruiting STEM-oriented UGs, finding summertime NavLab projects for eligible students, and the like.

Plan for UARCs

At the NAVSEA Recruitment Summit (August 2008) David Sivillo (Deputy Director, UARC Lab Management Office) presented a plan for preparing new hires for accelerated career development called "Graduates Ready For Tasking." This plan, executed during students' academic careers, would provide foundational skills, e.g., military protocol, mission awareness, the Navy's strategic vision, etc., plus short courses in topics such as sonar systems, hydrodynamics, coatings technology, etc. Sivillo's plan would give additional substance to our proposed UARC plan, and our plan would, in turn, further Sivillo's vision. Obviously, without payback mechanisms attached to educational support, such a program would have little effect. However, with payback, Sivillo's plan would certainly generate incoming new STEM employees who are much better prepared in terms of non-academic aspects of their new NavLab jobs. A complete, integrated program that combines both of the above with our suggestions (below) about summertime NavLab employment for Navy-funded (hence payback-obligated) students, should produce extremely well-prepared incoming employees with excellent chances of success and retention.

The Navy needs to require that all UARCs acquire and maintain data on students' work and degrees associated with the UARCs, on those STEM positions that are available and those filled, and on the number of Navy-funded UG and graduate students, and postdocs enrolled in their institutions, regardless of the details of that funding.

Developing a UARC database is a critical and difficult problem, i.e., getting data that bear on the success or return on investment (ROI) of various educational programs in which the Navy participates. Even were such elementary data as "number of people contacted" available (and it is not), the data would not necessarily bear any relationship to the actual problem being addressed, namely more STEM worker-years in the NavLabs. The highly prestigious, expensive, long-standing NDSEG Fellowship program cannot produce a list of the recipients' names – much less where they went for work. ***The Navy needs to require that all UARCs (and, incidentally, all other funded institutions) acquire and maintain data on Navy-funded students' work and degrees***, on those STEM positions that are available and those filled, and on the number of Navy-funded UG, and graduate students, and postdocs enrolled in their institutions, regardless of the details of those students' funding. This must become an explicit requirement.

We have, therefore, undertaken an internal examination of APL-UW records, assuming that the educational process here is in many senses a microcosm of the overall Navy effort on STEM above the K→12 level. APL-UW can serve "*in loco* NavLab," as a surrogate NavLab, because many of the STEM "attractors" and problems researched at APL-UW resemble those at NavLabs. APL-UW is also [simultaneously] effectively a STEM university: it brings in and funds undergraduate, graduate, and postdoc students using a

variety of monies (USN, DoD, Army, Air Force, NASA, NSF, NIH, industry, work-study) and does this in many ways (scholarships, as RAs on grant proposals, as postdocs, through REU programs, ASERTs, student work-study employment, etc.).

We are just completing an initial list of all STEM degrees granted via APL-UW since 1989. This is a non-trivial but doable task to identify those students' topical areas, whether they had USN or other DoD support as students, and where they went upon graduation. We plan to extend this to the other UARCs in Year 2. It may be both possible and worthwhile to discover the actual amount and specific source of Navy support received. If we are then able to track the students (entirely via word-of-mouth through their major professors) to their employment, we will be able to study the size of any effect, and to roughly estimate the cost-effectiveness (albeit on small scales) of Navy funding on NavLab employment (e.g., total program cost divided by lab worker-years).

Disturbing preliminary APL-UW results

Out of 154 masters and doctorates granted by UW for work done at APL-UW (1998–2007 inclusive), to date we have identified exactly one individual who went from APL-UW into a NavLab (NRL). This may not be all that surprising, because no requirement for NavLab employment was part of the programs in which those students participated, nor has there ever been any program or effort to suggest NavLabs as a career option upon graduation. These data strongly support our argument to make such requirements mandatory in a UARC Plan and to actively recruit UARC grads. [See App. L: Plan for UARCs for details of the plan and its implementation.]

ROI – nearly zero???

Once again, it must be pointed out that none of the programs through which these 150+ degrees were funded was designed specifically to address the NavLab STEM problem. Although these preliminary APL-UW data contain no specifics about USN funding for the graduates, we do know (from interviews with the students' major professors) that many students were supported by funds from a variety of Navy sources. Hence, if the observation holds true, i.e., "one graduate employed at a NavLab" out of >150 advanced degrees granted over 20 years (mostly with some Navy support), then we have a near-zero ROI, relative to the problem of "more STEM employee-years at the NavLabs."

However, many APL-UW graduates are now employed at APL-UW itself, which is presumably an indirect benefit to the Navy's research enterprise. Several have become STEM university faculty elsewhere (another probable indirect benefit), and still others have gone into defense-related industries such as Boeing (yet another probable indirect benefit). Such **data are critical to design a final Strategic Plan (e.g., to deciding what**

existing elements might be kept, modified, or discarded, and what new elements need to be designed), and especially to implement any plan.

What else should the Navy do?

What follows is a further discussion of specific actions – some already mentioned – that the Navy needs to undertake to move forward. These actions *assume that the paradigm shift in thinking has been or will be set in place* and that these actions, in some part, result from that shift.

9) Set up a high-level Navy mandate, with central command and control and central funding, for implementation of the Strategic Plan

10) Set up performance metrics to evaluate the Strategic Plan in alternate years

11) Keep adequate records about contacts

Set up a new, permanent, dedicated, central record-keeping and data processing facility. Considerable data-processing capability is needed, because a critical function is to identify (and pursue) individual students who have repeated contact with Navy E&O programs. **Require that all STEM educational efforts in which the Navy participates immediately begin collecting contact information for all participants, and for all applicants (both successful and not) for any Navy STEM program, award, and the like.** Data required are simple. (E-mail and U.S. mail addresses for both student and parents would suffice: those data can be requested on any application or entry form, and if legally required, a check-box included which says, "Check here if we may use these addresses to supply you with information on Navy financial aid for higher education in STEM fields, and about civilian STEM careers at Navy Laboratories.") This requirement can be imposed on all programs, but the individual programs must not be expected to do anything beyond collect and forward the data to the new central facility that will do the record-keeping, data analysis, and establish and maintain Navy-student contact over several years for each student.

12) Pursue contacts: especially pursue repeat contacts

Reinforce participants' experience with Navy programs by "keeping in touch." For this, the Navy must develop new, informative, and persuasive brochures (under the new humanist paradigm and HSMP) that explain opportunities and reasons for financial support and eventual STEM careers at NavLabs. These materials must be continually updated and given regularly to all contacts, and, when feasible, to contacts' parents. They should be

available at all Navy-supported events, most technical meetings, etc. Contact should not cease until well after graduation (or upon request).

13) Require identification and tracking of all Navy-supported students

Every student, at any level, who is supported by any form of Navy money, must be identified and their contact information provided to the central C&C data facility, by either the school or the responsible individual (e.g., PIs on ONR research grants). Pursue these students vigorously, and educate them further about STEM careers at NavLabs.

14) Actively expose all Navy-funded students to NavLab STEM R&D and careers

Although this is not a new idea (some E&O programs already do so), we stress that the Navy should **require (and pay) Navy-funded STEM UGs to take a ten-week summer job at a NavLab**, i.e., working on actual projects alongside career NavLab STEM personnel. Extend the requirement to all Navy-funded graduate students regardless of the specific source of their funding (e.g., whether won in a national Navy competition, provided via their major professor from an ONR research grant, etc.). Consider, too, the strong incentive to any PI to develop such projects, so as to get and hold graduate students: the closer the academia–NavLab connection, the better.

Fund the NavLabs to cover any expenses of doing this (no unfunded mandates!). Give each student the 10 weeks of support as a transportable mini-fellowship. Let each student choose his/her NavLab and apply directly to NavLab R&D personnel for an invitation into a specific project. As an added incentive to sponsors, provide $2k of unrestricted funding to each student's selected program. Reward NavLabs for superior performance in attracting such students. Point students to the central jobs website. Encourage students to look beyond the list and develop their own opportunities by talking with NavLab STEM personnel about projects. Have an annual face-to-face meeting of that year's summer-work students, hosted at a major NavLab; collect students' experiences and put them on the new central jobs website for next-year's web browsers.

15) Fund sufficient undergrads to meet specific projected NavLab needs

The number of UG funded in year N should be commensurate with (i.e., greater than) the projected NavLab "unmet" need for BS and MS personnel at year N+4 and N+5. "Unmet need" is the best estimate (based on historical data) of the difference between total projected need and predicted recruitment from non-Navy-funded STEM sources. This requires understanding projected future NavLab STEM needs well enough to enable an annual decision as to how many students to initiate, and in what general STEM fields (which need reflects back to basic data to be collected in Year 2).

16) Provide undergraduate support

Develop a high-visibility, prestigious, competitive program to support UG STEM students. Carefully select, and then **fully fund** STEM UGs from entry through BS, MS, or PhD as the student chooses. Allow more advanced STEM students to opt into support. Selection might be partly by national competition or all/partly through on-campus selection by Navy representatives during incoming orientation or pre-enrollment periods. Such a program would be best started exclusively at PUIs in cooperation with UARCs. **Require payback mechanisms per App. H and #18 below.**

17) Concentrate initially on primarily undergraduate institutions

Begin with UG support at PUIs (including HBCUs and other minority-intensive institutions) which have: (a) good STEM BS programs; and (b) experience in the humanist approach to STEM recruitment and retention. With experience, extend this to other PUIs, HBCUs, and to major institutions having both extensive UG and graduate programs: begin the extension at UARCs where the Navy has greater control over outcomes.

18) Require quid-pro-quo or payback mechanisms

The Navy must insist on a return in the form of employment at a NavLab for its investment in a student. This is a critical keystone element and worth repeating here as it applies to Navy STEM educational support. [See App. H.]

19) Continue to enlist help of, and train, high-school teachers and counselors

This should be a high-priority, carefully designed, well-funded effort because it can have large and rapid ROI. Through HSMP the Navy should begin immediately to develop informative and persuasive brochures (minimally two: one for employment possibilities, another for educational opportunities) **specifically for use by school career and educational guidance counselors, including private counseling services that help students and families locate financial aid**. These people are high-volume, high-efficiency contact 'pressure points'; efforts aimed at them must be a top Navy priority and must be thoughtful and professional in every way. This requires focused efforts to identify and then educate and excite counselors about Navy STEM opportunities for their students. It requires a plan to educate STEM teachers and high-school counselors about Navy opportunities so that they may inform their students, and is best accomplished as part of a national media campaign (HSMP) to help develop focused STEM educational materials for K$\rightarrow$12, and especially G9$\rightarrow$12. Some pieces of this are already being done in places like Virginia, San Diego, and Keyport ,WA. [See App. B, C, and D, respectively.]

20) Expand cooperative work with other agencies to leverage their efforts

Get students' contact information from other agencies (e.g., NSF) and from programs that generate lists of STEM-interested high school students (e.g., National Merit Scholarship Program and others, perhaps even private foundations that support STEM students). This might require, e.g., that students check a box on their application to authorize access.

21) Early-career award

(a) **Establish YIP-like awards**, given annually, competitors to be within +/– one year of PhD in a Navy-relevant STEM field. These awards should be portable (like a MacArthur genius award) to do research for X years at a NavLab TBD by recipient and candidate NavLab.

(b) **Reinstate ASERT.** We have found this is the most missed "dead" program for graduate students and is held in extremely high regard by those who participated in it, whether as faculty or students.

22) Help STEM graduates with job selection

Provide dedicated help (i.e., beyond the recommended central website) for seniors and graduate students to identify and choose the site of their "repayment" employment. This should be a mixture of: (1) live human help; and (2) advanced postings of type "available STEM careers at NavLab XX – contact Dr. Y directly to discuss."

23) For NavLab jobs, give 'selection points'

We recommend establishing a 'selection points' system (like veteran's preference) to applicants whose education was Navy-funded.

24) Revamp hiring rules at NavLabs

Hiring rules should be changed to eliminate obstructions to hiring now posed by stopper lists.

25) Set up job-locking

Allow, for example, final-semester Navy-funded STEM students to lock in a specific job pre-graduation. (This may require #24 above).

26) Help advance current NavLab STEM personnel

Develop a Navy-wide initiative that encourages and actively supports NavLab employees to advance their STEM educational levels while in-house, via Navy-funded continuing

education. Study San Diego's long-standing New Professional Program for implementation ideas.

27) Recruit retiring active-duty military STEM personnel from all services

Aggressively recruit retiring active-duty STEM-trained military personnel (especially Navy) into NavLab "2nd careers." Encourage the return to school, thence to NavLabs, of retiring or quitting blue-suit STEM personnel (e.g., under "quid-pro-quo" Navy funding).

28) Conduct external evaluations of Strategic Plan performance

Frequently, (e.g., alternate years) evaluate performance of all elements of the Strategic Plan using outside evaluators.

29) Examine other school systems around the world

Particularly in Asia, India, and Great Britain, where they produce more STEM graduates than does the U.S., seek additional ideas that may be applied in Navy programs to increase the number of STEM graduates.

Proposed Action Plan with Summarized Recommendations

1. Establish Navy mandate with central C&C and funding for Strategic Plan implementation

2. Set up performance metrics for external, alternate-year evaluation of the Strategic Plan

3. Establish 20–50-year view (promulgate paradigm shift)

4. Get basic QFLD data

5. Address K→Gray (KGSP) through tracking of promising STEM students (and all supported students), and clearly promote the Navy's availability of education funding and jobs for civilian STEM professionals

6. Finish the design, and formalize, the de-novo long-term Strategic Plan

7. Develop one central website for civilian STEM careers, jobs, and educational support

8. Develop humanist-oriented STEM media plan (print, web, promotional items, video, TV, radio, tech society meetings, etc.)

9. Overhaul Navy websites

    a. Develop website template for NavLab websites with central support and in concert with preliminary plans for the new Humanist STEM Media Plan

    b. Launch Humanist STEM Media Plan

10. Implement new outcome-based metrics (with tracking) for all Navy E&O efforts

11. Focus on undergraduate and masters students; develop competitive funding programs to meet specific, projected needs for STEM personnel

12. Require Navy-funded STEM UGs to take 10-week paid summer job at a NavLab

13. Focus initially on primarily undergraduate institutions (PUIs)

14. Focus on women and minorities (now) and Hispanics (25–50-year plan)

15. Maximize use of UARCs

16. Tie Navy support for grad students and postdocs to NavLabs' needs

17. Establish payback mechanisms now and develop materials in concert with the new Humanist STEM Media Plan

18. Continue best practices E&O programs (particularly those in VA, CA, and WA), but augment to include tracking and payback mechanisms

19. Evaluate all Navy E&O programs for duplication and/or missing elements (e.g., grade level, target audiences, geographic location, etc.) and present results in matrix-view for use in Navy assessment and planning

20. Advise SPAWAR Pacific to pare and streamline their numerous programs for a more focused, manageable approach over time

21. Continue NavOps Deep Submergence, SeaPerch, and ROV Challenge Programs with stable, ongoing administrative funding beyond December 2009

22. Partner with NSF's STCs to leverage K→9 with informal education in Navy-relevant disciplines

23. At a centralized facility, keep records about, and pursue, all E&O contacts including rejects

24. Continue to train and enlist help of high-school teachers and counselors

25. Expand cooperation with other agencies to leverage their and Navy efforts

26. Establish early-career awards for work at NavLabs

27. Help STEM graduates with job selection

28. Give "selection points" for NavLab jobs

29. Revamp hiring rules at NavLabs

30. Set up "job-locking" for final-semester Navy-supported STEM students

31. Help advance current NavLab STEM personnel

32. Recruit retiring active-duty military STEM personnel for 2nd careers at NavLabs

33. Examine international school systems that produce more STEM graduates than does the U.S.

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Appendix A: E&O Programs — Navy and Non-Navy

Note: Non-Navy programs are presented here for leverage purposes and/or for more detailed evaluation in the future. *This list is uneven and in flux and does not represent all E&O programs.*

Grades K→5

MESA, Mathematics Engineering Science Alliance, SSCSD, UW, and others

Floating Learning Lab, hands-on water and in-lab experience at Poulsbo Marine Science Center, WA, grades 3→6, sponsors: Poulsbo Marine Science Foundation, NUMF, Naval Undersea Museum Foundation, City of Poulsbo

National Science Foundation and other organizations' programs to attract STEM students

Science and Technology Centers in many cities emphasize STEM learning

Accelerated Progress Programs (APP) (Grades 1→8) emphasize STEM

Academically Gifted (AG) and Highly Academically Gifted (HAG) Programs emphasize STEM for gifted students under 18

U.S. First Robotics, engaging K→12 students in exciting mentor-based programs that build science, engineering and technology skills, that inspire innovation, and that foster well-rounded life capabilities **http://usfirst.org/who/default.aspx?id=34**

High Tech Fair at Del Mar: 2005–2009, over 1,000 K→12 San Diego students come to this fair once a year to get a taste of science. In 2009, SSCPac for the first time pays STEM participants half time and will have four tables of experiments. SSCPac Public Affairs generated.

San Diego Science Festival: 4 April 2009, K→12→adults, SSCPac responsible for over one dozen lectures in community schools plus four booths of demonstrations. **http://www.sdsciencefestival.com/**

"The Science of You" in Balboa Park. Free to public. Expo Day is the pinnacle event of San Diego Science Festival (SDSF), the West Coast's largest celebration of science. Science takes over the museums, cultural centers, and the central corridor of Balboa Park with over 300 hands-on activities, demonstrations, experiments, contests, and performances. Expo Day is for families, teens, and adults looking for a day of fun and discovery. Activity categories: "Your Art," "Your Body," "Your Planet," "Your Heroes," "Your Discoveries," "Your Sports," "Your Future," and "Your Transit." The festival also offers

over 500 free events throughout March. San Diego Science Festival is a collaboration of over 100 leading science organizations and is facilitated by BioBridge, a program of UC San Diego."

Grades 6→9

MATHCOUNTS, National enrichment coaching and competition program, 26 years

Tabula Digita, Curricular Materials/Teacher Professional Development, math in adventure video game format, 2003 Manhattan's Silicon Alley

Materials World Modules, Curricular Materials/Teacher Professional Development, kit-based curriculum enhancement for middle and high schools that combines the inquiry of science with the design of engineering. Students work in groups (3–4) to design projects. MWM Workshop in Maryland summer 2008 was sponsored by DoD giving participating teachers support from a DoD lab during the next academic year. The inquiry based material comprising the workshop was developed at Northwestern University with funding provided by NSF and is being implemented in middle and high schools throughout the country with DoD funds. **http://www.materialsworldmodules.org/**

SEAPerch, pre-designed student-built ROVs, grades 7→10, NUWC, Keyport, MIT, SNAME, Society of Naval Architects and Marine Engineers, and others

CCTE, College Career and Technical Education initiative, SSCSD

PEP, Pre Engineering Partnerships, summer research institute, opportunities for college engineering students helping K→12, National Defense Education Program (McGahern) with collaborators http://www.ndep.us/ProgPEP.aspx

NavOps Deep Submergence, virtual and practical application curriculum for math, science, communication, teamwork, NUWC, Keyport/Naval Undersea Museum Foundation, local schools, business, and industry

Seaglider, virtual modeling to real-world curriculum, NUWC, Keyport/Naval Undersea Museum Foundation

CASE, Center for the Advancement of STEM Education, (age group ?), 2006 DoD

U.S. First Robotics, engaging K→12 students in exciting mentor-based programs that build science, engineering and technology skills, that inspire innovation, and that foster well-rounded life capabilities **http://usfirst.org/who/default.aspx?id=34**

UW Robinson Scholars, (grades 7→UG)

Virginia Demonstration Project (VDP), (grades 7→9) Dahlgren: ONR-funded program launched 2004 as part of N-STAR (Naval Research - Science and Technology for America's Readiness). VDP was initiated to show a diversity of pre-teens and teens – the critical age group for establishing a life-long interest in STEM – that math, science, and engineering are fascinating, fun, and socially relevant. VDP emphasizes problem-based learning. Students use robots, computers, Powerpoint presentations and movies they wrote, narrated, and produced to explain their creative solutions to save lives, clean oil spills, and clear mines from land and water.

21st Palms, K→12, 2008 only, San Diego. Palm Beach County School District Science Fair hosted by Department of Defense Research & Engineering (DDR&E). For one day four SSCPac STEM professionals drove their energy sources developed for soldiers; 300 K→12 students.

Science Nights: 2007–2009, at San Diego middle schools four times annually. SSCPac hosts about a dozen science demonstrations throughout the school for the students and their families – often used as a fundraiser through the sale of refreshments. SSCPac brings 15 paid STEM professionals. Began in 2007 with one school.

Girl's Day Out (GDO): (five events, beginning November 2008–2009), a science and engineering fair for middle-school girls at UCSD and SDSU. Middle school girls gain the opportunity to explore STEM subjects while on a college campus. Began with 35 girls and increased with each event to 45, 60, 70 (plus parents and external volunteers—college-aged women) from schools all over San Diego. Anywhere from 15–25 SSCPac STEM professionals are paid their salary for time spent at the events. NDEP sponsors GDO, paying for the room, lunch, snacks, goodie bags, award for speaker, tables, and IT support. The event consists of a greeting, followed usually by two STEM professional women speakers, followed by tours of campus and about eight demonstrations, then lunch, more of the same, ending with a speaker from the university talking about careers.

San Diego Science Festival: 4 April 2009, K→12→adults, SSCPac responsible for over one dozen lectures in community schools plus four booths of demonstrations. **http://www.sdsciencefestival.com/**

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over 100 leading science organizations and is facilitated by BioBridge, a program of UC San Diego."

ENSPIRE: 2008, about 400 8th graders spend a half day with the UCSD Physics Department. SSCPac provides funding for about one dozen STEM professionals to perform various science demonstrations that are SSCPac generated.

Expanding Your Horizons: 2009, 500 middle school girls at University of San Diego. Eighteen SSCPac STEM professionals in six classrooms (1-hour lectures and demos) where they instruct girls in various science and engineering topics. SD Science Alliance generated; ad hoc for some years prior to current practice.

High Tech Fair at Del Mar: 2005–2009, over 1,000 K→12 San Diego students come to this fair once a year to get a taste of science. In 2009, SSCPac for the first time pays STEM participants half time and will have four tables of experiments. SSCPac Public Affairs generated.

Grades 10→12

PEP, Pre Engineering Partnerships, summer research institute, opportunities for college engineering students helping K→12, NDEP, National Defense Education Program (McGahern) with collaborators **http://www.ndep.us/ProgPEP.aspx**

SLM, STEM Learning Modules, hands-on classroom activities, NDEP, National Defense Education Program (McGahern)

SEAP, Science Engineering Apprenticeship Program, $1,500 paid to students for eight weeks work during the summer with STEM professional at Navy labs on R&D projects of interest to the Labs. ONR Education Outreach Program, administered by American Society for Engineering Education

NSAP, Naval Science Awards Program, recognition, incentives, scholarships ($2 – 20,000) for participants in regional and state science fairs, administered by American Academies, ONR Education Outreach Program, Dr. Anthony Junior, Program Manager, sponsor: Academy of Applied Science

ISEF, International Science and Engineering Fair in conjunction with NSAP, 20 students annually receive $8,000 in portable scholarships, ONR Education Outreach Program with Marine Corps

JSHS, Junior Science and Humanities Symposium, undergraduate tuition scholarships awarded, 10,000 participants annually, sponsors: universities and DoD: Army, Navy, Air Force

SEAPerch, pre-designed student-built ROVs, grades 7→10, NUWC, Keyport, MIT, SNAME, Society of Naval Architects and Marine Engineers, and others

ROV Challenge Program, grades 11→12 students launch ROVs they've designed and built, since 2005 doubled annually to 14 school districts, 5 high schools, 8 teachers, over 430 students, and 8 support organizations (UAS, Underwater Admiralty Sciences, Inc., Lockheed-Martin, NUWC, Naval Undersea Warfare Center, Keyport, Raytheon, Northup-Grumman, British Aerospace Engineering, sailors at Trident Submarine base, Bangor, NUMF) in conjunction with SEAPerch. Potential for funding from NSF Math Science Partnership Program

Materials World Modules, Curricular Materials/Teacher Professional Development, kit-based curriculum enhancement for middle and high schools that combines the inquiry of science with the design of engineering. Students work in groups (3–4) to design projects. MWM Workshop in Maryland summer 2008 was sponsored by DoD giving participating teachers support from a DoD lab during the next academic year. The inquiry based material comprising the workshop was developed at Northwestern University with funding provided by NSF and is being implemented in middle and high schools throughout the country with DoD funds. **http://www.materialsworldmodules.org/**

CASE, Center for the Advancement of STEM Education, (age group ?), 2006 DoD

RSI, Research Science Institute, long-term assistance, sponsors: MIT and Center for Excellence in Education

STEP, Student Temporary Employment Program, SCCSD summer work for students

Seaglider, virtual modeling to real-world curriculum, NUWC, Keyport/Naval Undersea Museum Foundation

U.S. First Robotics, engaging K→12 students in exciting mentor-based programs that build science, engineering and technology skills, that inspire innovation, and that foster well-rounded life capabilities **http://usfirst.org/who/default.aspx?id=34**

UW Robinson Scholars, (grades 7→UG)

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San Diego Science Festival, 4 April 2009, K→12→adults, SSCPac responsible for over one dozen lectures in community schools plus four booths of demonstrations.
http://www.sdsciencefestival.com/

APL-UW TR 0901

"The Science of You" in Balboa Park. Free to public. Expo Day is the pinnacle event of San Diego Science Festival (SDSF), the West Coast's largest celebration of science. Science takes over the museums, cultural centers, and the central corridor of Balboa Park with over 300 hands-on activities, demonstrations, experiments, contests, and performances. Expo Day is for families, teens, and adults looking for a day of fun and discovery. Activity categories: "Your Art," "Your Body," "Your Planet," "Your Heroes," "Your Discoveries," "Your Sports," "Your Future," and "Your Transit." The Festival also offers over 500 free events throughout March. San Diego Science Festival is a collaboration of over 100 leading science organizations and is facilitated by BioBridge, a program of UC San Diego."

High Tech Fair at Del Mar, 2005–2009, over 1,000 K→12 San Diego students come to this fair once a year to get a taste of science. In 2009, SSCPac for the first time pays STEM participants half time and will have four tables of experiments. SSCPac Public Affairs generated.

St. Mary's Academy HS Summer Internship, 2008–2009, G10→12, mostly G11. Ten girls spend one month at SSCPac working with a STEM professional to see what scientists and engineers do. The girls are from Englewood (L.A.) and do not have many STEM role models in their lives. Funding total $17K (split between NDEP and ONR) pays girls $1,000 and pays housing @ $33.00 day. ONR works through **SEAP**, Science Engineering Apprenticeship Program, ASEE, to pay out these funds.

Career Days, 2008–2009, G6→9, SSCPac provides four STEM professionals twice annually for local schools; two or three schools are combined in one location. STEMs bring a robot and are paid.

Judging, 2009, G6→12, SSCPac provides a dozen or so science judges on an ad hoc basis for SD science fares; one school they go to each year and spend the day. Reach about 400 students. Can pay up to eight volunteers.

Lectures, 2009, G6→12, Developing a toolbox of lectures for SSCPac STEM professionals to bring to classrooms. Been to six schools. Began January 2009. Often held in school auditoriums. **Speech recognition** – lecture and demo developed by one SSCPac speech recognition professional. **RF Seek** – SSCPac's electromagnetic group built receivers and transmitters so teams of students can navigate about.

Science Decathlon, 2009, G10→12 competition held at Grossmont Community College; about 200 students expected. SSCPac provides demos and posters.

National Merit Scholarship Program, academic competition for recognition and scholarships, begun in 1955. High school students enter by taking the Preliminary SAT/National Merit Scholarship Qualifying Test (PSAT/NMSQT®)–a test that serves as an initial screen

of approximately 1.5 million entrants each year–and by meeting published program entry/participation requirements. Privately funded, not-for-profit corporation.

Undergraduate

PEP, Pre Engineering Partnerships, summer research institute, opportunities for college engineering students helping K→12, NDEP, National Defense Education Program (McGahern) with collaborators **http://www.ndep.us/ProgPEP.aspx**

HBCU, Historically Black Colleges and Universities, strengthens capacity of HBCUs to provide excellence in education, public and private schools, schools have land-grant status, Dr. Anthony Junior, Program Manager, National Association for Equal Opportunity in Higher Education represents all HBCUs

REU, Research Experience for Undergrads, Curricular Materials/Teacher Professional Development

SMART, Science Math and Research for Transformation, scholarship for service, National Defense Education Program (McGahern), Administered by Naval Postgraduate School in cooperation with American Society for Engineering Education

NREIP, Naval Research Enterprise Internship Program, 10-week summer internship program at Navy labs with STEM professional working on R&D project of interest to the Lab, 139 annually, stipend: $5,500 month, administered by American Society for Engineering Education

CISD, Center for Innovative Ship Design in conjunction with NREIP, NSWC Carderock

SCEP, Student Career Experience Program, SCCSD, paid internship for 2- and 4-year colleges, integrated with SSCSD work and can lead to employment at SSCSD

STEP, Student Temporary Employment Program, SCCSD summer work for students

UW Robinson Scholars, (grades 7→UG)

NSF's Robert Noyce Teacher Scholarship Program, helps prepare STEM undergraduate majors and STEM professionals to become K→12 science and mathematics teachers in the neediest schools.

NAIP, Naval Acquisition Intern Program trains promising young college graduates in naval acquisition for NAVSEA, which employs more than 50,000 people to engineer, design, build, and maintain the U.S. Navy's ships and combat systems, including aircraft carriers, surface ships, and submarines. NAIP intern positions are full-time, paid positions

NSF/N-STAR Civilian Service Scholarship Program (NNCS), ONR, under the Naval Research - Science and Technology for America's Readiness or N-STAR program, partner with the National Science Foundation (NSF) and the Navy. College juniors and seniors and graduate students receive fellowship money and incur a service obligation as civil service employees in a naval research and development center. ONR teams new junior level scientists and engineers with a seasoned employee to start the transfer of corporate knowledge to the next generation. Numerous in-house applied fesearch projects team three or four junior level people with a senior level scientist. A leadership component is built into the scholarship program. Students, who are from the top universities in the country, step away from their studies for three days to do a self-assessment about their careers and their future leadership roles in the Navy's science and technology community.

MS and PhD Programs

HBCU, Historically Black Colleges and Universities, strengthens capacity of HBCUs to provide excellence in education, public and private schools, schools have land-grant status, Dr. Anthony Junior, Program Manager, National Association for Equal Opportunity in Higher Education represents all HBCUs

SMART, Science Math and Research for Transformation, scholarship for service, National Defense Education Program (McGahern), Administered by Naval Postgraduate School in cooperation with American Society for Engineering Education

NREIP, Naval Research Enterprise Internship Program, 10-week summer internship program at Navy labs with STEM professional working on R&D project of interest to the Lab, 139 annually, stipend: $6,500 month, administered by American Society for Engineering Education

Presidential Early Career Awards for scientists and engineers, honor young professional achievement, National Science and Technology Council with collaborators, 2006

NDSEG, National Defense Science and Engineering Graduate fellowship, to be awarded April 2009: 200 new 3-year fellowships at $50,000 per year per student, administered by American Society for Engineering Education

New Professional (NP) Program: Began early 1960s. MS–Postdocs. NP is the primary means to introduce recent graduates in engineering and science to SSCPac's workforce to bridge the gap between academic training and professional work. SSCPac typically hires 75–100 talented, entry-level technical professionals per year into the 6-month rotational program, which is part of a two-year developmental training program that includes both formal and on-the-job training. SSCPac supports the development, acquisition, and fielding of leading-edge C4ISR systems for Navy, Joint, and Allied customers.

NSF/N-STAR Civilian Service Scholarship Program (NNCS), ONR, under the Naval Research - Science and Technology for America's Readiness or N-STAR program, partner with the National Science Foundation (NSF) and the Navy. College juniors and seniors and graduate students receive fellowship money and incur a service obligation as civil service employees in a naval research and development center. ONR teams new junior level scientists and engineers with a seasoned employee to start the transfer of corporate knowledge to the next generation. Numerous in-house applied fesearch projects team three or four junior level people with a senior level scientist. A leadership component is built into the scholarship program. Students, who are from the top universities in the country, step away from their studies for three days to do a self-assessment about their careers and their future leadership roles in the Navy's science and technology community.

Postdoc and Early Career Development

NSSEFF, National Security Science and Engineering Faculty Fellowship, extensive, long-term funding to university faculty scientists and engineers to conduct unclassified basic research, National Defense Education Program (McGahern), DoD and Director Defense Research and Engineering

NSF's Robert Noyce Teacher Scholarship program, helps prepare STEM undergraduate majors and STEM professionals to become K–12 science and mathematics teachers in the neediest schools

YIP, Young Investigator Program, new faculty at colleges and universities conducting naval research, FY09 projection: 24 new awards at $170,000 annually plus matching opportunities

Summer Faculty Research Program, Faculty San Diego, ONR sponsors U.S. citizens or legal permanent residents who hold teaching or research appointments at U.S. colleges and universities. The Summer Faculty Research Program lasts 10 weeks. Opportunity for faculty members to participate in research of mutual interest to the faculty member and SSCPac mentors.

Sabbatical Leave Program, Faculty San Diego, ONR sponsors U.S. citizens or legal permanent residents who hold teaching or research appointments at U.S. colleges and universities. Lasts between one semester and one year. Opportunity for faculty members to participate in research of mutual interest to the faculty member and SSCPac mentors.

Historically Black Colleges and Universities (HBCU) Future Engineering Faculty Fellowship Program, Designed to develop and attract qualified engineering faculty to Historically Black Colleges and Universities (HBCUs) with engineering programs. Each year, three recipients who have agreed to join the engineering faculty of an HBCU after

receiving their degrees are competitively selected for study and research support leading to doctoral degrees in engineering. Disciplines include the following: aerospace engineering, electrical engineering, mechanical engineering, manufacturing science and engineering, civil engineering, ocean engineering, chemical engineering. ONR-HBCU Future Engineering Faculty Fellowship stipends are set each year at a competitive level. In addition to stipends, the program pays the Fellow's full tuition and fees (not to include room and board). **http://www.onr.navy.mil/sci_tech/3t/corporate/hbec.asp**

External but Related Programs: Leverage Through Partnerships

Local Science and Technology Centers around the country offer the opportunity for informal education activities particularly relevant for the Navy as a way to address K→6 grades.

"Coalitions should be encouraged and funded everywhere. Such coalitions should promote interactions among K→12 school systems; 2- and 4-year colleges and universities; informal science education organizations; . . . to promote learning and the development of the STEM skills needed for the 21st century. (National Science Board, p. 3) Neither can the nation as a whole nor the Navy ignore any opportunity to further STEM awareness.

National Science Foundation programs to be funded through the Recovery Act:

- K→12, Math and Science Partnership program (funded at $25 million)

- K→12, Robert Noyce Teacher Scholarship Program (funded at $60 million)

- MS Grad, Science Masters program (funded at $15 million).

- MS /PhD Grad, NSF Graduate Research Fellowship Program (GRFP) Nordic Research Opportunity. The Division of Graduate Education and the Office of International Science and Engineering offer an international research opportunity, available as a Supplemental Award, for NSF Graduate Research Fellows (GRFs) in the early stages of their degrees to enable Fellows to gain international research experience and establish collaborations with counterparts at Norwegian or Finnish research institutions.

Appendix B: The Virginia Demonstration Project

Background and Description

The Virginia Demonstration Project (VDP), a program within the Office of Naval Research launched in 2004, is part of N-STAR (Naval Research - Science and Technology for America's Readiness). VDP recognizes that the critical age group for establishing a life-long interest in STEM is 7th and 8th graders. N-STAR's purpose is the development of the next generation of Navy scientists and engineers to ensure that the Department of the Navy maintains a leading edge in warfighting technologies for national defense. N-STAR director Kirk Jenne of ONR works under the leadership of the Chief of Naval Research Rear Admiral Nevin Carr, Jr., in cooperation with the Navy's warfare centers.

VDP was initiated to show a diversity of pre-teens and teens, primarily seventh and eight graders, that math, science, and engineering are fascinating, fun, and socially relevant. VDP is problem-based learning. Students use robots, computers, Powerpoint presentations and movies they wrote, narrated, and produced to explain their creative solutions to save lives, clean oil spills, and clear mines from land and water. Student interest is piqued by showing students real-world problems and challenging them to find practical solutions, which is one of the major successes of VDP. For example, in 2006, students chose how unmanned surface, undersea, and air vehicles are used to address the world's landmine problem. Why would they pick such a problem? Because they learned that children are the largest worldwide population affected by landmines. This was something they could relate to and care about.

Key Components for Success

VDP teams of six to eight students are from a cross section of disciplines including math, science, English, and art. Students used creativity to come up with solutions and their knowledge of other subjects to write up reports and make displays to present their completed projects. Further, VDP is open to all students from participating schools—not just the gifted and talented—and, there are no prerequisites or entry fees. Plus, it's a regular part of the school day. VDP is also encouraging female and minority students to challenge conventional thinking about their natural aptitudes in math, science, or engineering.

Seventh and eighth graders and their teachers have the opportunity to work in their classrooms side-by-side with practicing Navy scientists and engineers on technological projects designed to solve problems faced by today's warfighters. The Navy mentors, in turn, develop an appreciation and understanding of the challenges that teachers face every day in the classroom. Approximately 50 scientists and engineers were from NSWC Dahlgren alone.

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VDP Evaluation Results

Researchers at the College of William and Mary, McLaughlin Associates, Virginia Tech, the Naval Surface Warfare Center, Dahlgren Division, and the Office of Naval Research conducted a study in 2007 of the Virginia Demonstration Project and published their findings, "Evaluating a Comprehensive Middle School Outreach Program—The Results," in the *Proceedings of the 2008 American Society for Engineering Education Annual Conference & Exposition.*

"In the three years of its existence, the Virginia Demonstration Project, a middle school STEM outreach program supported by the Office of Naval Research, has grown to reach more than 3000 7th and 8th graders in its academic year and summer camp programs, to involve more than 80 science and math teachers in its professional development activities, and to employ the services of nearly 50 Navy scientists and engineers who work side-by-side with the teachers in the classroom as facilitators, mentors, and role models.

"This paper describes how, in the context of a comprehensive logic model, comparison-group, pre- and post-testing, and focus group mixed-method (quantitative and qualitative) studies have been used to determine in a statistically significant fashion how the interventions of which this program consists can be tied to the measured achievements. Changes in the skills, knowledge, and attitudes of the teachers and students [are] described as well as the influence of this program on changing student attitudes toward possible STEM careers. The human subjects-based research was conducted with the approval of the Institutional Review Board of the College of William & Mary.

"The results show that as a result of participating in the program, **students have an increased interest in pursuing STEM careers and that they exhibit increased knowledge in and ability to use science and mathematics**. Teachers indicate a high level of support for problem-based learning, which is a fundamental component of the program. The results are presented in a form of valuable results and broadly transferable methodologies that will inform a variety of K12 STEM outreach activities."

By the end of the **2006–2007** school year, **3042 students, 86 teachers and 48 scientists and engineers** had participated in the VDP. **Fifty school counselors** had participated in the counselor education programs. **Ten different sets of professional development training activities** were provided to professional co-teaching teams. Seventh and eighth graders in the public school systems in three counties immediately surrounding the NSWCDD were involved: Stafford, King George, and Spotsylvania counties.

The Navy Perspective

From a Navy perspective, the essential feature of the Virginia Demonstration Project was to determine whether Naval Warfare Center scientists and engineers could effectively

team with teachers in the classroom to stimulate a greater long-term interest among middle school students in science and mathematics. VDP addresses the strategic vulnerability that our future Navy will face as a result of these generational, educational, and budgetary realities. The program is exploring whether working scientists and engineers with their real-world experiences can help shape positive perceptions about math and science among middle school students. More specifically, VDP is testing whether we can inspire more young people to see the value and relevancy of a future career in science or engineering by:

- Showing pre-teens and teens that math and science are fascinating, fun, and socially relevant

- Encouraging female and minority students to challenge uninformed thinking about their natural aptitudes in math, science, or engineering

- Providing middle school teachers with opportunities to team teach with practicing scientists and engineers

- Leveraging the mentor-rich environment that we still have in our Naval Warfare Centers to help draw new talent into our science and technology workforce

The VDP Steering Committee agreed that the core elements of the program on which its evaluation would be based were:

- To generate and sustain the interest and excitement of adolescents in careers in mathematics, physics, engineering and or other sciences

- To enhance the effectiveness of science and mathematics instruction

- To strengthen family and school support for students' (particularly females and minority students) achievement and interests in career paths in mathematics, science, technology and engineering

- To develop a cadre of Navy scientists and engineers for continuous outreach to educational communities as a part of their professional responsibilities

- To develop, document, and evaluate the project

The research team for the VDP learned that additional dedicated personnel are needed to support efficient and reliable data collection.

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2006 VDP

VDP has a broad base of support both in words and deeds at all levels from the Virginia Senator's Office, ONR, Naval Surface Warfare Center (NSWC) Dahlgren Division, the county school districts, and the universities.

"We were able to see science and engineering in real jobs doing real things for all of us," said Dr. Jean Murray, Superintendent of Stafford County public schools. "Teachers and educators broke out of their familiar day-to-day routines to work with Navy scientists and engineers to enable our students to see, feel, hear and touch science, math and engineering through our robotics program. Our students learned more than science and math — they have learned about creativity and problem solving and how to learn by sharing information."

> *'N-STAR definitely changed my mind,'* smiled Kaitlin McDonough, an *H.H. Poole Middle School seventh grader after giving a brief about how to clean up an oil spill and protect coral reefs and marine life.* *'Before our project, I saw math as just numbers. Now, it's a whole different subject that I think everyone should have a chance to learn. Engineering is for everyone because everyone can do it.'*

"Although this program was developed to encourage young people to consider careers in technical fields, working with these young minds reinvigorated me and made me more appreciative of my work," said Bruce Copeland, a Strategic and Weapon Control Systems Department engineer who mentored students at Chancellor Middle School. "With all the reports about the inability of young people to concentrate on a single task, it was enlightening to see the focus and intensity of purpose that some of the young men and women could bring to bear on solving a complex problem. It improves my outlook for the future of our nation."

Erin Swartz, a Joint Warfare Applications Department aerospace engineer who is planning to mentor VDP students again in the future said, "Once they discovered that there wasn't just a single right answer, they became quite creative and came up with solutions I would never have thought of."

VDP's ultimate goal is to establish educational outreach programs at other Navy research and development centers throughout the country. VDP Managers believe the initiative could eventually expand beyond the Navy and evolve into a national demonstration project encompassing all the DoD laboratories in a sustained effort to secure the long-term competitiveness of America's science and technology workforce by hooking more kids on math and science at an earlier age. As a result, the number of students earning university degrees in science, mathematics, engineering, and technology will exponentially increase.

Recommendations

While the goals and core elements for evaluation are laudable we don't think they're as aggressive as they need to be to address the STEM problem. Again, they lack any well-founded payback plan. And, in fact, the VDP researchers admitted that the "… long-term connection between participation in the VDP and academic achievement and future employment decisions is less clear at this time." One can't fault them for that but the Navy should encourage VDP management to ask more of their program, let these students know that Navy Labs need them, and track these students into the future.

We heartily agree that the expansion of VDP into research and development centers throughout the country is the direction the Navy should take, but with one caveat: up the ante and tell students, parents, teachers and counselors that the Navy wants these students to consider a civilian STEM career in the Navy, and that they have one to offer. Consider extending a nonbinding letter of intent that parents sign.

Sources

NSWC, Dahlgren **http://www.nswc.navy.mil/NEWS/NSTAR/article.html**

CHIPS - The Department of the Navy Information Technology Magazine N-STAR article **http://www.chips.navy.mil/archives/06_Jul/web_pages/NSTAR.htm**

Juanita J. Matkins, J. McLaughlin, E. Brown, G. Hardinge, N. West, B. Stiegler, K. Jenne, "Evaluating a Comprehensive Middle School Outreach Program—The Results," *Proceedings of the 2008 American Society for Engineering Education Annual Conference & Exposition,* 2008, American Society for Engineering Education

Appendix C: SPAWAR Systems Center Pacific E&O Programs 2007–2009

Notes:

- SSCPac initially focused on high school but now their focus is mainly on middle schools because there are too few women in the high schools who are interested in STEM.

- Currently about 68 external, unpaid volunteers, mostly students, help carry out these programs.

- 2009 is SSCPac's second year of having funding for their programs to include half-time funding for SSCPac's STEM professionals. SSCPac receives $250K annually from NDEP.

Recommendation

We recommend paring and streamlining these programs for a more focused approach. We suggest this given the sheer number of these programs (22), the real possibility of burnout, and no metrics or data are available at this point to evaluate their potential effectiveness in addressing the STEM Problem.

1) K→12––adults, San Diego Science Festival: 4 April 2009

SSCPac responsible for over one dozen lectures in community schools plus four booths of demonstrations. **http://www.sdsciencefestival.com/**

"The Science of You" in Balboa Park. Free to public. Expo Day is the pinnacle event of San Diego Science Festival (SDSF), the West Coast's largest celebration of science. Science takes over the museums, cultural centers, and the central corridor of Balboa Park with over 300 hands-on activities, demonstrations, experiments, contests, and performances. Expo Day is for families, teens, and adults looking for a day of fun and discovery. Activity categories: "Your Art," "Your Body," "Your Planet," "Your Heroes," "Your Discoveries," "Your Sports," "Your Future," and "Your Transit." The Festival also offers over 500 free events throughout March. San Diego Science Festival is a collaboration of over 100 leading science organizations and is facilitated by BioBridge, a program of UC San Diego."

2) K→12, High Tech Fair at Del Mar: 2005–2009

Over 1,000 K→12 students come to this fair once a year to get a taste of science. In 2009, SSCPac for the first time pays STEM participants half time and will have four tables of experiments. SSCPac Public Affairs generated.

3) K→12, 21st Palms: 2008 only

Palm Beach County School District Science Fair hosted by Department of Defense Research & Engineering (DDR&E). For one day four SSCPac STEM professionals drove their energy sources developed for soldiers; 300 K→12 students.

4) K→12, Partnerships with K-12 Schools: 2008–2009

Four schools and hope to grow a presence as well as an opportunity to improve the value SSCPac can bring by finding out what the schools need.

5) G6→9, Science Nights: 2007–2009

At San Diego middle schools four times annually. SSCPac hosts about a dozen science demonstrations throughout the school for the students and their families – often used as a fundraiser through the sale of refreshments. SSCPac brings 15 paid STEM professionals. Began in 2007 with one school.

6) G6→9, Girl's Day Out (GDO) (5 events, beginning November 2008–2009)

A science and engineering fair for middle-school girls at UCSD and SDSU. Middle school girls gain the opportunity to explore STEM subjects while on a college campus. Began with 35 girls and increased with each event to 45, 60, 70 (plus parents and external volunteers—college-aged women) from schools all over San Diego. Features keynote speakers including University Assistant Dean of Engineering. Booths range from herpetology to liquid nitrogen demonstrations. Individuals from the SD County Office of Education in February 2009, hosted a booth about recycling.

Three unpaid military personnel, attached to SSCPac, often participate. Middle and high school girls do not get paid but SSCPac provides high school girls with a paper of authentification to use for college transcripts. College volunteers also do not get paid but they receive recognition from the school. If funds are available, SSCPac compensates participants' time in the classroom. Anywhere from 15–25 SSCPac STEM professionals are paid their salary for time spent at the events. NDEP sponsors GDO, paying for the room, lunch, snacks, goodie bags, award for speaker, tables, and IT support. The event consists of a greeting, followed usually by two STEM professional women speakers, tours of

campus, about eight demonstrations, lunch, more of same, ending with a speaker from the university talking about careers.

7) G6→9, Career Days: 2008–2009

SSCPac provides four STEM professionals twice annually for local schools; two or three schools are combined in one location. STEMs bring a robot and are paid.

8) G6→9, Expanding Your Horizons: 2009

Five hundred middle school girls at USD. Eighteen SSCPac STEM professionals in six classrooms (1-hour lectures and demos) where they instruct girls in various science and engineering topics. SD Science Alliance generated; ad hoc for some years prior to current practice.

9) G6→9, First Robotics: 2009

All SD middle schools participate in robotic teams. SSCP provides a robotics expert and classes and helps parents who captain robotic teams. SSCPac STEM professionals will help with the teams. Part of the first national robotics group, which costs $35K per student to compete nationally at a series of events.

10) G8, ENSPIRE: 2008

About 400 8th graders spend a half day with the UCSD Physics Department. SSCPac provides funding for about a dozen STEM professionals to perform various science demonstrations that are SSCPac generated.

11) G6→12, Lectures: 2009

Developing a toolbox of lectures for SSCPac STEM professionals to bring to classrooms. Been to six schools. Began January 2009. Often held in school auditoriums. **Speech recognition** – lecture and demo developed by one SSCPac speech recognition professional. **RF Seek** – SSCPac's electromagnetic group built receivers and transmitters so teams of students can navigate about.

12) G6→12, Judging: 2009

SSCPac provides a dozen or so science judges on an ad hoc basis for SD science fares; one school they go to each year and spend the day. Reach about 400 students. Can pay up to eight volunteers.

13) G6→12, Partnerships with Universities: 2008–2009

Informal partnership with UCSD, SDSU and soon USD to find student volunteers for SSCPac's E&O programs. SSCPac also looking for mentors from a Historically Black College or University (ONR pays $12K).

14) G6→12, Partnerships with City and Local Industry: 2009

SSCP talking to City of San Diego, Qualcomm, NDIA and are making some headway in a search for funding and STEM professionals to volunteer in the schools along with SSCPac.

15) G6→12, Material World Modules (MWM): 2008-9

Kit-based curriculum enhancement for middle and high schools that combines the inquiry of science with the design of engineering. MWM Workshop in Maryland summer 2008 was sponsored by DoD giving participating teachers support from a DoD lab during the next academic year. The inquiry based material comprising the workshop was developed at Northwestern University with funding provided by NSF and is being implemented in middle and high schools throughout the country with DoD funds.

The Deputy Director of Research and Engineering (DDR&E) has asked SSCPac to put together a strategy for SSCPac to be the DoD lab that is the California hub for DDR&E K→12 outreach. FY08, SSCPac trained about 50 teachers and 12 SSCPac scientists and engineers. MWM is implemented in about a half dozen schools in SD.
http://www.materialsworldmodules.org/

16) G10→12, mostly G11, St. Mary's Academy HS Summer Internship: 2008–2009

Ten girls spend one month at SSCPac working with a STEM professional to see what scientists and engineers do. The girls are from Englewood (L.A.) and do not have many STEM role models in their lives. Funding total $17K (split between NDEP and ONR) pays girls $1,000 and pays housing at $33.00/day. ONR works through **SEAP**, Science Engineering Apprenticeship Program, ASEE, to pay out these funds.

17) G10→12, Science Decathlon: 2009

High school competition held at Grossmont Community College; about 200 students expected. SSCPac provides demos and posters.

18) G11→12, SEAP: ONR partnership

About 10 high school students (U.S citizens) per summer come to SSCPac to work with STEM professionals on any of a number of SSCPac's R&D projects. $1,500 paid to students for eight weeks' work. St. Mary's Academy has been encouraged by ONR to participate in this summer high school internship program and this is bearing fruit.

19) UG→MS / PhD, NREIP: ONR partnership

About 28 university interns (U.S citizens) per summer come to SSCPac to work with STEM professionals on any of a number of SSCPac's R&D projects. $5,500 stipend for UGs; $6,500 for MS / PhDs for 10 weeks' work.

20) MS→Postdocs, New Professional (NP) Program: Began early 1960s

NP is the primary means to introduce recent graduates in engineering and science to SSCPac's workforce to bridge the gap between academic training and professional work. SSCPac typically hires 75–100 talented, entry-level technical professionals per year into the 6-month rotational program, which is part of a two-year developmental training program that includes both formal and on-the-job training.

SSCPac is the Navy's premier research, development, test, and evaluation laboratory supporting command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR). SSCPac supports the development, acquisition, and fielding of leading-edge C4ISR systems for Navy, Joint, and Allied customers. It is a $1.4 billion organization with 3700 government employees that includes 2000 technical professionals. Of the technical professionals at the Center, 8% have a PhDs, 29% have masters degrees, and 63% have bachelors degrees.

Recent graduates in science and engineering begin their careers at SSCPac through NP, working for three months each in two groups on technical projects related to a graduate's background and interests. This initial period provides the opportunity to experience various types of work and get to know SSCPac. Afterwards, NPs transition to a permanent position in one of SSCPac's technical departments:

- Command and Control

- Communications and Information Systems

- Intelligence, Surveillance, and Reconnaissance and Information Operations

- Navigation and Applied Sciences

- Fleet Engineering

SSCPac likes to foster the innovative thinking that recent college graduates bring to the workforce. New Professionals are treated as valuable resources whose input is immediately respected in the team. Funding is also available to pursue higher degrees and continued training throughout an employee's career. Since SSCPac's product installations are worldwide, afloat and ashore, employees could find themselves on temporary duty assignments to foreign locales from Australia to Uzbekistan.

21) Faculty, Summer Faculty Research Program

ONR sponsors U.S. citizens or legal permanent residents who hold teaching or research appointments at U.S. colleges and universities. The Summer Faculty Research Program lasts 10 weeks. Opportunity for faculty members to participate in research of mutual interest to the faculty member and SSCPac mentors.

22) Faculty, Sabbatical Leave Program

ONR sponsors U.S. citizens or legal permanent residents who hold teaching or research appointments at U.S. colleges and universities. Lasts between one semester and one year. Opportunity for faculty members to participate in research of mutual interest to the faculty member and SSCPac mentors.

Appendix D: NavOps Deep Submergence, SeaPerch, and ROV Challenge with Funding Proposal

Naval Undersea Museum Foundation
PO Box 408 Keyport, WA 98345
360-697-1129

Since 1999, the Naval Undersea Museum Foundation (NUMF) has worked to improve science curriculum and instruct K→12 teachers, affecting 50,000 students in fourteen Washington State school districts in Kitsap, Jefferson, Pierce, Clallam, and Mason Counties to form the Science Education Alliance. Several practical application programs were funded through FY07 via the Department of Defense, the U.S. Department of Education, and the state of Washington. Remarkably, these interrelated programs collectively address the entire spectrum of K→12 and into community colleges and the University of Washington.

The Marine Discovery Lab and Aquatic Zone are an elementary school (currently G3→6) marine science experience housed at the Poulsbo Marine Science Center. Through interactive exhibits and participatory laboratory experiences, the programs focus upon a student's understanding and appreciation of Puget Sound regional water systems as an integrated organism. The influences of industrial pollutants, improper sewage disposal, introduction of non-indigenous species, storm water mismanagement, etc., are studied and examined within marine and aquatic science content. A dynamic on-the-water learning laboratory allows hands-on analysis of such science principles as salinity, electrolysis, dissolved oxygen levels, zooplankton and phytoplankton counts and ratios, depth pressure, and turbidity. These are dynamic experiences tied directly to, and intended to make more meaningful, the essential science learner outcomes being taught in the classroom.

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Programming is offered for pre-schoolers and informal education at the Center. Partners in this endeavor include the NUMF, Poulsbo Marine Science Foundation, University of Washington, City of Poulsbo, and fourteen school districts in the Science Education Alliance (SEA). The Center sees more than 30,000 visitors per year and the education program served 700 students in 2008–2009, but is designed to serve up to 9,000 students per year. Funding for increased on-site programming is currently pending approval with the state of Washington.

The NavOps Deep Submergence Program targets middle school science learners and is a unique curriculum spanning 9–12 weeks of instruction. At the core are the basics of marine navigation, extending into marine and nautical science principles: ocean ecology, physical and chemical oceanography, physics of underwater sound, motion, and light as well as the electromagnetic spectrum. Students use this curriculum and submersible technology to gather data and solve environmental problems within a virtual/simulated "sandbox." Learning to work together as a team of four, student crews operate a virtual submersible using a wireless laptop and joystick. Up to seven submersible crews per classroom work to accomplish a common environmental mission.

Navigation data can stream out onto the Internet to allow other classrooms around the world to join in the same "sandbox" in real time to manage a common mission. This dynamic, interactive, and participatory program allows navigation teams to collaborate in a sophisticated virtual submersible mission/project. Each team member possesses a specialized level of expertise and knowledge to both communicate to teammates and apply to the mission. Application plus collaboration gives students the way to "construct" knowledge, resulting in a higher level of intellectual understanding. This engaging program has been successfully implemented at Bainbridge Island and North Kitsap school districts in Washington State and is also implemented at the Watson Academy for Boys in Gary, IN serving more than 900 students. The NavOps software program, supporting intellectual property, and trademark are owned by the Naval Undersea Museum Foundation.

SeaPerch

Integrating Ocean Exploration into the Classroom (G7→10) is a five to six week ROV building experience where students are mentored as they are introduced to underwater robotics. Students build their own propulsion system, develop the controller and investigate weight, buoyancy, and trim. The project culminates with a day at the pool where student teams of two are challenged to use their robots to explore, pick up objects, and maneuver an obstacle course. This program is currently deployed at Central Kitsap JrHS, Klahowya Secondary School, Ridgetop JrHS, and Fairview JrHS in the Central Kitsap School District.

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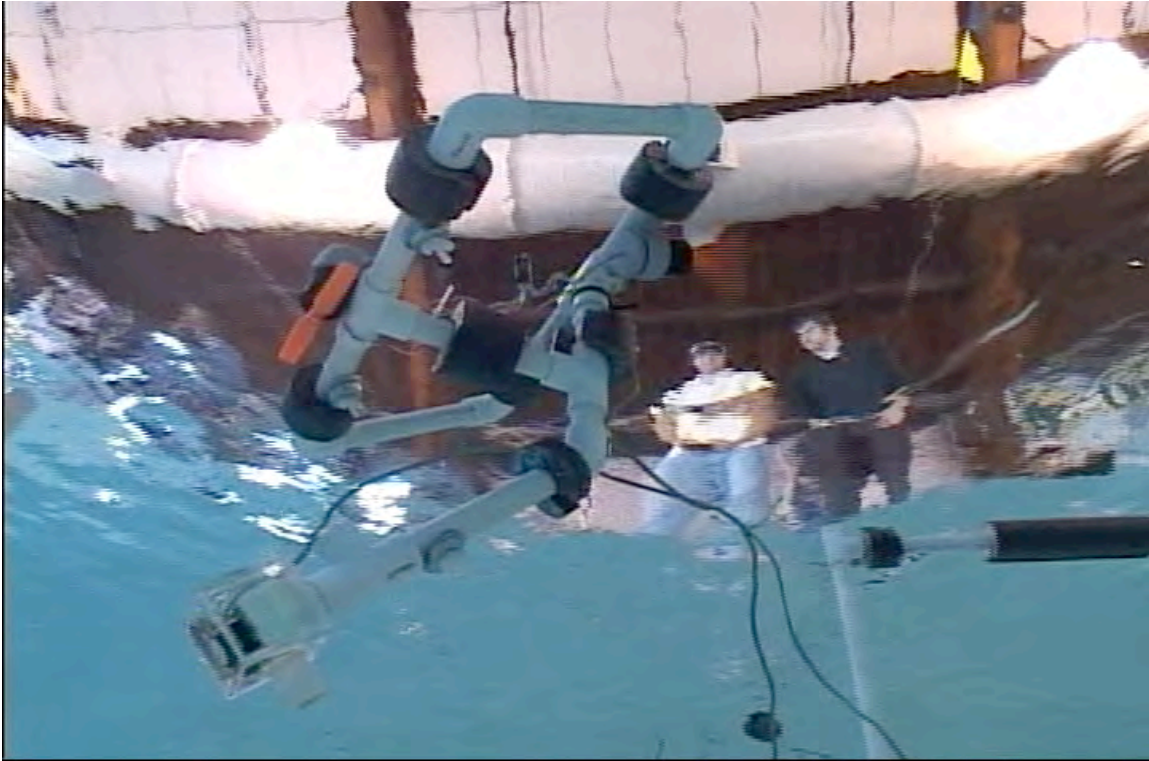
The Remotely Operated Vehicle (ROV) Challenge Program is focused on high school students in G11→12. The program is an application of concepts that can be integrated across a wide array of courses such as **advanced high school applied physics, physics, marine science, intro to engineering, and CAD/Adv CAD**, thereby affecting a large number of students. While teams of two students design, engineer, construct, test, assess, monitor, and adjust their own ROV in partnership with both peers and engineer mentors from industry, they apply classroom content such as force, motion, balance, displacement, and buoyancy. After designing and building ROVs, the students accomplish a number of tasks simulating real-world technical work on a mooring in disrepair. The intent of the ROV Challenge Program is to transform the conceptual learning to a higher level of knowledge that is solely acquired through application. That which was previously conceptual becomes dynamic and, thereby, more personally relevant.

Business and community interest and support specifically in the ROV program is significant. Private, non-profit, civil service, and Navy organizations are currently involved and participation is growing. **NUMF has partnered with a number of Navy military, civilian organizations, private and non-profit organizations, which donate or pay for time to support these programs. Over 80 volunteers** gave repeated technical advice and provided in-pool and other support for the culminating ROV Challenges during the 2007–2008 school years. **Program collaborators in the ROV Challenge and Sea Perch**

Programs are: the Naval Undersea Warfare Center Division Keyport, Lockheed-Martin, Raytheon, Northrop-Grumman, British Aerospace Engineering, Transient Personnel Unit (TPU) Submarine Base Bangor, Puget Sound Naval Shipyard, USS *Emory S. Land* divers, Underwater Admiralty Sciences, Inc., and Naval Undersea Museum Foundation. Additionally, a long list of individual volunteers is available from the organizations and community on an as-needed basis to provide off-duty time to the program.

Currently, more than one dozen partners support these programs. The program significantly increased future registrations in the initial courses, and interest from other school districts has doubled each year until 2008–2009.

2005–2006 — 1 high school >100 students

2006–2007 — 2 high schools / 2 school districts >200 students

2007–2008 — 5 high schools, 2 junior highs / 3 school districts 440+ students

2008–2009 — 8 high schools, 4 junior highs / 4 school districts / nearing 520 students

Work is continuing to increase partners and develop supporting relationships for each of the above programs. Along with military / civilian, retirees, and active duty military commands, NUMF and NUWC, Keyport have started working toward relationships with higher education both at the local community college (Olympic Community College) and universities in the region (University of Washington) linked to each of the aforementioned programs.

Growth in all programs would be greater if not for limited administrative support personnel and support materials. Funding is the primary restriction. While there is some funding from industry, school districts, and DoD (Office of Naval Research, NAVSEA), NUMF has stretched funding to pay for program management until June 2009, and has secured temporary, one-time minimal funding through MIT until December 2009. Most other funding requirements (technical support, teacher training, ROV building and support materials) have been funded by various sources, including industry, private, and government sources.

NUMF's capacity to manage the ROV Challenge and SeaPerch Programs along with NavOps, and the Marine Science Center with only one person is now the limiting factor for growth. The waiting list for these programs alone now numbers more than 300 pending FY10 funding for an additional staff person.

Although these programs have had a relatively short life span and lack the metrics with which to evaluate the program's success and appropriateness for the Navy's ROI, gains have been achieved:

- The Navy and all partners involved are gaining excellent community relations

- Diverse student populations are being reached while exposing students to organizations of possible future employment

- The state and nation gain higher scholastic aptitude students

- The schools gain more interested students who have demonstrated significantly higher achievement in standardized testing

- The Navy and other organizations related to the Navy gain on-campus presence and a pool of possible future employees who have a positive impression of the service, know more about what the organizations do, and about the people who work there

- Navy and civilian families in the region benefit from their children's improved scholastic opportunities and increased student achievement

Budgets

FY09 Budget

1-FTE Program Administrator	$ 98K	Independent Contractor
1-PTE Fiscal and Admin Support	$ 18K	Independent Contractor
Supplies-materials-equipment	$ 19K	
TOTAL	$135K	

Steady state with all programs at current level: Marine Science Center receives <5 volunteer hours per week to manage tasks as needed to assure attendance of 600 students per year. NavOps Deep Submergence will continue to serve students in current programs. ROV Challenge and Sea Perch Programs will continue to serve 450–500 students annually with no additional growth.

Proposed FY10 Budget

1-FTE Program Administrator	$ 98K	Independent Contractor
1-FTE Curriculum Executive	$ 70K	Independent Contractor
1-PTE Fiscal and Admin Support	$ 18K	Independent Contractor
Supplies-materials-equipment	$ 25K	
TOTAL	$210K	

Steady state with all programs at current level: This budget would provide program administration to accompany pending program funds that would provide education programming for 3,300 students. NavOps Deep Submergence will continue to serve students in current programs but will start the curriculum documentation process. ROV Challenge and SeaPerch Programs will expand to serve a minimum of 800 students in 2009–2010. Processes and procedures can begin to be documented and established to be able to convey this successful program to others.

National Roll-Out

There are fifteen Navy museums (Navy History and Heritage Command) and many with non-profit 501(c)3 foundations like the Naval Undersea Museum Foundation. These foundations are uniquely situated to provide a link among the Navy military, civil service, contractor, and education partners with the ability to maintain a lean organization. Some of these museums are situated in close proximity to Navy technical personnel and would provide a natural starting place for implementation. When stand-alone funding is established in ONR, NETC or other at levels of FY11 (or year 1) for $1.2M, FY12 (or year 2) for $1.5M, and FY13 (or year 3) for $2.5M if a national program is ultimately desired, programs can be fully documented, curriculum developed, and software updated.

POCs

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Discussion

NavOps Deep Submergence, SeaPerch, and ROV Challenge at the Naval Undersea Museum Foundation (NUMF) and NUWC, Keyport, WA are in an active partnership with local schools, business, and industry. These programs are remarkably interrelated and span K➔12. Such efforts are in keeping with the National Science Board's recommendations concerning the need for parents, government, business, industry, foundations, scientists, and engineers to collectively draw attention to and develop local, high-quality

STEM education. "Coalitions should be encouraged and funded everywhere. Such coalitions should promote interactions among K→12 school systems; 2- and 4-year colleges and universities; . . . and business and industry to promote learning and the development of the STEM skills needed for the 21st century." (NSB, p. 3)

Coalitions are important on a number of fronts. The Museum, Warfare Center, the Puget Sound Naval Shipyard as well as business and industry collectively are engaged in a *"grow your own"* program to train and retain STEM professionals. They have found that if they hire scientists and engineers from outside the area, e.g., the East Coast, new hires leave after a couple years. The Puget Sound Naval Shipyard is working through local community colleges to attract new hires and is particularly distraught over the training dollars they've lost when people from outside the area leave.

The difference between these programs (**NavOps Deep Submergence, SeaPerch, and ROV Challenge Programs**) and any other science-based programs is that they are **applications-based, integrated with the core curriculum, and actively engage a large percentage of the population where implemented**. Although there have been no funds available to establish metrics and gather data, NUMF and NUWC, Keyport report that students are changing their future academic and employment plans, expressing new appreciation for and interest in the technical sciences and engineering because they collaborate with engineers and technical personnel to solve real engineering and navigational problems, and ultimately have a chance to gain insight into the world of ocean technology and engineering.

Appendix E: Navy Museums

Notes:

- Navy Museums are part of the Department of Navy History. See **http://www.history.navy.mil/museums/index.html**. A link on the left side of their main web page lists the museums and then links to each museum's web page. Below are the museums and their locations.

- Various education and outreach (E&O) programs could benefit from the union of Navy museum foundations with Navy warfare centers and/or Navy shipyards. Those proven E&O programs established among NUWC, Keyport, WA and the nearby Naval Undersea Museum Foundation and Puget Sound Shipyard should be leveraged and duplicated elsewhere in the country where Navy Museum Foundations are co-located with warfare centers, shipyards, or other Navy organizations.

- This list of the museum foundations is presented here for two key reasons: (1) Museum foundations have in place the critical administrative coordinator to move the programs forward in their communities; and (2) Foundations can ask schools, business, and industry to contribute funds and STEM volunteers to leverage the necessary consortium of contributors who work as a team.

1) Great Lakes Naval Museum, Naval Station Great Lakes, Illinois

2) Hampton Roads Naval Museum, Norfolk, Virginia

3) National Museum of Naval Aviation, Pensacola, Florida

4) Naval Museum of Armament and Technology, China Lake, California

5) Naval Undersea Museum, Keyport, Washington

6) Naval War College Museum, Newport, Rhode Island

7) Navy Art Collection, Washington, D.C.

8) Puget Sound Navy Museum, Bremerton, Washington

9) Patuxent River Naval Air Museum, Patuxent River, Maryland

10) Seabee Museum, Port Hueneme, California

11) Submarine Force Museum and Historic Ship *Nautilus*, Groton, Connecticut

12) U.S. Naval Academy Museum, Annapolis, Maryland

13) U.S. Navy Museum, Washington, D.C.

14) U.S. Navy Supply Corps Museum, Athens, Georgia

15) USS *Constitution* "Old Ironsides," Boston, Massachusetts (probably inappropriate as primarily a history museum)

Appendix F: Science and Technology Centers and Pacific Science Center Proposal

As **'informal' education centers** i.e., **Science and Technology Centers** provide learning outside the classroom that enhances and complements 'formal' (classroom-based) learning. Informal science education uses visual, auditory, physical interactions, and activities to engage children as it's designed to be fun, accessible, equitable, voluntary, self-directed, and hands-on. A recent report issued by the National Research Council (Bell et al., 2009) shows that student experiences gained in informal settings can significantly improve science learning outcomes, particularly for groups historically underrepresented in science.

The mission of **Pacific Science Center (PSC)** is to inspire a lifelong interest in science, mathematics and technology by engaging diverse communities through interactive and innovative exhibits and programming. PSC is a member of an international network of Science and Technology Centers, with over 300 members within the U.S. [the Association of Science and Technology Centers, ASTC (**http://www.astc.org/** and **http://www.astc.org/members/passlist.htm**)]. PSC has participated in numerous collaborative programs with other association members and piloted several programs that have been broadly adopted within the association.

PSC serves over 1,000,000 people per year on-site; its off-site programming reaches an additional 340,000 people, including 20,000 teachers and 75,000 students through school field trips. It provides science education in all 39 counties of Washington State each year, reaching another 160,000 people through visits to schools by the Science on Wheels van program; an additional 180,000 visitors are reached by our off-site enrichment activities at places as diverse as county fairs, community centers, community celebrations and Boy Scout events. Total reached: 1.680 million annually.

PSC's major programs:

- *Exhibits* – Permanent: Tropical Butterfly House, Insect Village, Body Works, Kids Works, Weather, Dinosaurs, Technology, and Robots. Traveling exhibits to other science centers around the world. Touring exhibits from other science centers covering topics not included in permanent exhibits.

- *Enrichment Education* – Environmental education programs at Mercer Slough in Bellevue, Summer Camps, Camp Ins (overnight camp programs), and Discovery Corps, a youth development and training program in which teens, many from disadvantaged neighborhoods, learn to serve as interpretive guides for exhibits and activities on the floor of the Science Center.

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- *Science on Wheels* – Van program that provides science education state wide on topics that include engineering, the human body, geology, mathematics, and astronomy. Programming includes school assemblies, exhibits, and classroom activities focused around the van's thematic areas.

- *Leadership Assistance for Science Education Reform (LASER)* – Redesign of how science is taught to help teachers learn new, interactive, inquiry-based teaching techniques. LASER has helped approximately 100 school districts state wide and has been shown to significantly improve the effectiveness of science teaching in Washington.

- *Portal to the Public* – Through special events, publications, and activities the public is exposed to unfolding research that drives dialogue in science and technology issues of societal relevance.

- *Public Programs* – Demonstrations and planetarium shows occur daily; two IMAX theaters; top-of-the-line 3-D facility; special events built around a variety of themes.

Pacific Science Center Proposes to Further the Navy's E&O Mission

A partnership involving informal and formal learning communities (universities, K→12 schools, science centers, museums) could have a significant impact on enhancing awareness of Navy-relevant disciplines and associated careers among K→12 and university students.

Pacific Science Center seeks to leverage its relationship with the public of Washington State, its innovative programming on STEM issues, and its role as an influential member of a national network of Science and Technology Centers to further the Navy's objectives of nurturing the pipeline of U.S. scientists and engineers in Naval relevant disciplines, helping develop programs that expand the diversity of U.S. researchers and research institutions, and raising public awareness of and interest in the Navy. To accomplish this, we propose the following programs.

SeaPerch Summer Camp

SeaPerch, a two-week program for grades 6–9 builds previously designed ROVs. It is an innovative hands-on educational activity that provides students with the opportunity to learn about robotics, engineering, science, and mathematics while building an underwater ROV as part of a science and engineering curriculum. Students learn engineering concepts, problem solving, teamwork, and technical applications, as well as have the opportunity to participate in an end-of-camp design competition to be scheduled at a local pool. SeaPerch time is also devoted to a discussion of potential careers in technical and engi-

neering fields and the courses students should be taking to participate in those relevant disciplines. Visits from graduate students, postdocs, and researchers from the University of Washington in relevant fields will be integrated into the camp experience. SeaPerch Camp will inform and educate students through hands-on activities with the goal of generating interest and enthusiasm for continued science, technology, and engineering studies.

SeaPerch has been immensely successful, but thus far it has only been implemented and evaluated in the context of formal education. The proposed program would be the first implementation of SeaPerch in an informal educational context. PSC has successfully adapted formal science curriculum to the informal context for several programs; their capabilities in this regard have been documented by Gibbons et al. (2008), *Recasting Content in a New Light: A Guide for Adapting Formal Education Materials for Informal Settings,* produced for NASA. Adapting the formal curriculum for the informal setting significantly broadens the audience for SeaPerch by expanding the context in which it can be offered. Program evaluation will make it possible to determine the effectiveness of a camp setting for introducing students to the SeaPerch activities and content. PSC will work closely with the team that developed the formal curricular materials for SeaPerch to ensure the adapted, informal materials achieve all critical programmatic objectives.

SeaPerch Camp teachers will be recruited from programs in relevant disciplines at the University of Washington and trained on content, inquiry-based learning, as well as specifics relevant to SeaPerch in a professional development course held prior to the start of the camp season. SeaPerch camp teaching assistants (TAs) would be recruited from PSC's Discovery Corps (DC) program, a career ladder program that recruits teens from populations underrepresented in science and engineering fields, immerses them in interactive science and engineering activities, while providing valuable job and leadership skills with one-on-one mentoring by caring adults. TAs would undergo an analogous professional training program. All students are welcome to apply and participate, but scholarships will be reserved for students from groups that are underrepresented in the STEM disciplines or that come from schools where >75% of the student body receives free or subsidized lunch.

SeaPerch Camp will be extensively evaluated and documented; program information will be disseminated at the ASTC annual meeting as well as at annual meetings of relevant professional associations such as the Marine Technology Society, the Society of Naval Architects and Marine Engineers, the Oceanography Society, and the Oceanic Engineering Society. Long term, we will also seek support from these societies both in defraying the cost for students and to 'get out the word' about the camp more broadly in the U.S.

To support a broader dissemination of the SeaPerch Camp, PSC will develop training materials and conduct professional development courses for prospective instructors from other sites to ensure consistency of content and instructional approach.

SeaPerch After School

Science programs that take place after school can increase interest in science as well as awareness of STEM careers (Dierking, 2007; Dierking and Falk, 2002). After school programs for low-income students can provide enrichment opportunities that are often only available to those who can afford to pay for them (National Research Council, 2009) and can make a difference in their lives (Walker et al. 2005, National Research Council, 2009). "After school settings are optimal for providing engaging hands-on STEM experiences, enabling students to apply, reinforce, and extend skills and concepts taught in school. And they are particularly conducive to project-based activities where a wide variety of children can participate in the design, construction, investigation, sense-making and communication of science projects. . . . Furthermore, the time for such experiences in after school programs is more flexible than in formal education, and the agenda can change when questions lead to deeper inquiry" (Coalition for Science After School, 2004). "Moreover, students from underrepresented communities can gain the necessary skills to compete in formal science classrooms" (Afterschool Alliance, 2008).

Framed in this context, **SeaPerch After School** (SPAS) introduces grades 6→9 to various science and engineering concepts addressed by SeaPerch. PSC proposes to offer SPAS either on-site during after school programs at various schools, or at organizations such as the YMCAs or Boys and Girl's Clubs. YMCAs offer the advantage of a pool, though arrangements could be made for access to local pools for SeaPerch testing and competition. Through Discovery Corps (DC), PSC teens, 40–60 youth annually, serve as mentors to teen participants. Depending on the duration of program participation, DC teens receive between 25 and 100 hours of professional development and training in exhibit interpretation, and over time transition from volunteer to paid positions. Teens gain progressively increasing responsibilities and are promoted accordingly within the program. All aspects of the DC program – training, mentoring, exhibit interpretation, and visitor interaction – work together to provide a continuing succession of technical and scientific training designed to inspire a lifelong interest in the STEM disciplines.

SPAS provides additional training and content knowledge specific to SeaPerch to participating DC members and teachers. The DC teens work in conjunction with trained teachers from PSC's Science on Wheels educational program, one of the largest science outreach programs in the country that brings STEM-themed lessons, exhibits, and activities to schools, libraries, community centers, fairs, and festivals. These teachers have backgrounds in science, mathematics, education, and theatre, and receive special training in content and methods specific to informal science education.

While the formal SeaPerch curriculum is recast for the informal context, we will use evaluation mechanisms from targeted after school programs to determine the optimal format for offering SeaPerch in the after school setting, i.e., once per week for ten weeks, or once per day for two weeks; two-hour sessions per visit, or one-hour sessions. PSC will work with the developers of the SeaPerch formal curriculum to determine best practices that convey all essential content, but are appropriate for the after school setting.

Pacific Science Center already has a strong relationship with many after school providers in the Seattle area, and it is also an active member of several networks of after school providers, such as Schools-Out Washington, the New York Hall of Science's Science Career Ladder program, the Afterschool Alliance, and the Coalition for Science After School. Once the SPAS program is effectively piloted in Seattle, PSC will work with these organizations, as well as the ASTC network to scale up this program in other geographic areas.

Appendix G: Preliminary Strategic Plan Tasks 1–4

Task 1: Acquire Data About the NavLab STEM Problem

Basic data, which have never been collected and which we propose to collect in various ways (Year 2), include "QFLD":

- ***Quantity:***   *How many new STEM people will the NavLabs need?*

- ***Fields:***   *In what specific fields?*

- ***Levels:***   *At what specific educational levels (BS, MS, PhD)?*

- ***Dates:***   *By what specific dates?*

It would also be useful, but not critical, to know **where** (geographically) those needs will occur.

Task 1(a) The QFLD data will be developed through visits and interviews at NavLabs

The collection efforts need not be particularly onerous for the Labs, but to ensure quick and accurate response we will need supporting directives from high levels of the Navy's administration. The data need not be exhaustive: a small number of large NavLabs will include a large fraction of the total STEM personnel, and can be taken (collectively) as a good representation of the system's overall state and needs. Part of the Strategic Plan is to collect such data (updated) perhaps every two or three years, for use in adjusting Navy investment strategy in STEM education, particularly undergraduate.

Task 1(b) In parallel with gathering QFLD data, we will collect information via an email survey (in Year 2) of NavLab STEM personnel

This will be very helpful in the detailed design and implementation of the final Strategic Plan, and in developing augmentations to existing efforts. We propose a short electronic questionnaire be sent to all NavLab STEM personnel asking for very simple information. Questionnaires will be returned to a [new] central site for collation and analysis. The answers bear directly on how much effect various Navy/DoD programs have on the NavLab STEM problem, and on what aspects might be either used or improved or both:

- What is your STEM field of education?

- What is your highest STEM degree?

- What STEM field are you actually working in, regardless of your degree-field(s)?

- During your STEM education, were you ever supported by monies from any part of DoD? (Please name the program if you recall.)

- During your STEM education, were you ever supported by specifically Navy monies? (Please name the program if you recall.)

- During your STEM education, did you ever visit, work at, or study at a NavLab? (If so, why and which Lab?)

- Your total years as a NavLab employee in STEM (sum up all NavLab positions held)?

- Did you work in STEM before coming to a NavLab? If so, for how long?

- How did you find out about STEM careers at NavLabs? (friend, teacher, advertisement, counselor, accident, WWW, etc.)

- Have you personally ever successfully recommended a NavLab STEM career to anyone? (Success means the person actually took a STEM position at a NavLab – regardless of for how long.)

The need for such "questionnaire" data is high, both for firming up details of the Strategic Plan and for evaluating present STEM educational efforts as to their impacts on the STEM problem. Again, to ensure reasonably accurate data, those employees must: (a) be required to reply [via high-level directive]; (b) not be required to search through their personal records or provide either a lot of information or details; and (c) be informed of both the reasons for, and the results of, the survey. This exercise should be repeated (~ every 5 years) within the Strategic Plan, as a check on the plan's actual performance.

Task 2: Develop Performance Metrics, Track and Engage Students

Task 2(a) Metrics

The core is to develop performance metrics for existing E&O programs. Those metrics will require both identification and tracking all participants (recipients, volunteers, winners, losers). For the two types of performance metrics – process and outcome – wherever possible we will emphasize outcome metrics over process. The outcome metric of greatest concern here is "more STEM employee-years at NavLabs." Not all Navy STEM educational efforts have obvious outcome metrics, particularly metrics that can be connected directly to the NavLab STEM problem: an example is K→9 efforts. For such programs, we suggest either internal outcome metrics such as growth of participant numbers over time, or using process statistics such as the number of hits on a data access website developed by participating organizations, and other data.

Task 2(b) Tracking

To our knowledge, no existing Navy STEM educational programs presently tracks the students who participate – e.g., from high school into and through college, much less into careers. This lack includes efforts at all levels (K$\rightarrow$postdoctoral). The most egregious examples are from higher levels: (a) the Navy participates in the NDSEG Fellowship program, which over the past 20 years has supported ~2000 STEM graduates students for three years each. That program cannot produce a list of names of the students supported, and the program does no education or follow-up with the 90% of self-declared STEM students who apply, compete, and are not funded; (b) ONR's research grants to academia routinely include extensive (and expensive) support for graduate students, postdocs, and undergraduates, but there is no requirement for either the investigators or the schools to provide any data (including mere lists of names) on recipients of such education funding – much less is there any requirement for "service in return for financial support" (as proposed herein). Every Navy STEM educational effort must include – if at all possible – specific efforts to track participants.

Task 2(c) Engagement

Engagment with students meshes with tracking. Participants in Navy STEM programs should be engaged by the Navy in various ways designed to further the students' interest in and access to Navy support for STEM education, and to help **both students and parents** understand and explore possibilities for Navy educational funding and for NavLab STEM careers. (A convinced parent can be the Navy's strongest ally, and most parents have more than one child.)

Soft engagement techniques include requiring every student participant in G9$\rightarrow$G12 programs (and especially those students who compete for various awards) to provide a contact address (email, U.S. mail) for both him/herself and parents, so that the Navy can regularly provide them with information on educational, financial, and career possibilities (EFC information). To assure consistency, this must be a centralized effort, although every implementation is ultimately local. Navy STEM educational efforts needs a centralized system for accumulating and using such data.

Hard engagement techniques are more aggressive: they include, e.g., working with high school staff to identify particularly good STEM-oriented students, and then establishing contact with them to provide EFC information, and actively selecting individuals for offers of summertime (juniors and seniors) research experience at NavLabs. Perhaps the greatest need is for hard engagement during undergraduate years – the Navy must develop programs of aggressive, effective mentoring and education of undergraduates (e.g., using its extensive network of funded faculty, graduate students, and postdocs). This will mean educating the candidate mentors as well. Hard UG contact should include not only aid and guidance in studies, but active promotion of extended, Navy-funded summertime

research experiences at NavLabs: contact with mentors should be concentrated on Navy-supported students, but must be broadly available so as to sweep in others as well.

E&O programs and metrics. We have already mentioned the need for data collection, and for a new centralized facility that will collect and process various data. In fact, "The research team for the Virginia Demonstration Project learned that additional dedicated personnel are needed to support efficient and reliable data collection." (VDP, p. 21)

We will use the data to ask questions such as: Should particular E&O programs – or specific parts of programs – be continued? If so, which ones? Why or why not? The answers to questions like these require metrics and data that are for the most part unavailable but will be collected. We do not fault these programs and their administrators for the paucity of data, because nearly all programs are neither funded nor tasked to establish metrics, nor to acquire, interpret, and maintain the resulting data. In light of these understandable facts a more immediate alternative presents itself. In Year 2, we would conduct a detailed examination of each program, its growth, its probable continuance and expansion, including its relationship to other similar programs in other locales near and far. Data would be captured in a database searchable by relevant fields and viewable in a matrix format. We want to see if the emphasis is too heavy or insufficient in various areas of the country and among particular grade levels and subject matters. What topics or areas are not covered? Where would the Navy receive its greatest ROI? Where would it be particularly advisable to partner with non-Navy programs? Are there areas of the country, or grade levels, which the Navy ought **not** engage? (This too should be on the table when looking at where the Navy might gain the most advantage for its efforts.)

The K$\rightarrow$12 problem and Navy efforts to address it are in general diffuse – e.g., trying "to increase interest in STEM amongst K$\rightarrow$6 students" – this is a difficult task, which has been extensively (and expensively) addressed at the national level for decades with only occasional success. At the local level, some efforts by individual Navy labs have had spectacular success, as judged by "K$\rightarrow$12 internal metrics" such as enthusiastic and rapidly-growing student participation, and requests by non-participating schools to expand local programs to their campuses. Such successful efforts to engage K$\rightarrow$12 students and teachers in STEM should be actively encouraged and supported by centralized resources. Every attempt should be made (centrally) to extract broad general principles and techniques, and to make those available to all Navy labs that are pursuing localized efforts. It should be core to any policy that local efforts must be primarily developed by local personnel to use local resources and to meet local conditions, but with support available centrally. Otherwise, the lack of sustained funding for coordination and administration means the programs will likely fall by the wayside. Always, everywhere, efforts to engage students should be paralleled by efforts to engage and inform those students' parents, teachers, and counselors about STEM educational and career opportunities within the Navy.

Metrics in K→12. Due to the diffuseness of the K→12 problem, most initial metrics for K→12 efforts must be "internal to K→12." One should not attempt to stretch for a causal connection between, say, hits on grade school-oriented websites and eventual NavLab employment. What one can do is measure parameters **internal to K→12 efforts** (i.e., as differentiated from metrics aimed at estimating the number of lab STEM worker-years acquired, e.g., number of web hits may be a fine internal metric but not be connectible to NavLab employment: number of students participating, number of K→12 teachers given STEM training and materials, number of teachers and students and guidance counselors directly exposed to materials explaining Navy STEM career opportunities and/or educational funding opportunities, and the like). There are undoubtedly some metrics from, say, G11→12, that could be directly correlated against eventual STEM employment in the NavLab system – e.g., tracking recipients of Navy-sponsored prizes and awards. Although there are some efforts, many such metrics are either not being collected today or are collected in an unusable format.

Metrics in UG→Gray. Beyond K→12 we have compiled a list of programs (Appendix A) that already indicate the potential for obtaining data once metrics are chosen. Our efforts here are ongoing, and the list does not yet fully address Gray. We believe that UG→Gray programs can be connected to K→12 efforts in a number of ways that could aid the pipeline, and, thereby, unify the Navy's address of the problem. Please see **Appendix I: K→Gray STEM Plan** for possible ways to make those connections.

Task 3: Design a Long-term Strategic Plan

This is a solution specifically for the NavLab STEM problem that will use what works from existing programs, and propose new approaches where they seem most needed and likely to be effective. A genuine Strategic Plan requires a significant paradigm shift in Navy thinking about the problem, extension of the plan across several decades, and into pre-adaptation of Navy STEM strategies to inevitable long-term demographic changes in the nation.

Task 4: Evaluate and Augment Current K→Gray and Additional New Programs

Task 4 takes a very pragmatic, and optimistic, view of current Navy STEM educational efforts. There are manifold reasons for those efforts, and the efforts were not intended to address the STEM-NavLab problem, hence there is no fault to be found with any program for failure to do so. Task 2 is essentially an analysis of what the Navy is doing and how to improve it in various ways, with a special eye towards improvements that specifically address an approach to the NavLab STEM problem that could yield quantifiable effects. However, realistically, those efforts to improve existing programs' productivity and interconnectivity and efficiencies will not by themselves result in or constitute a co-

herent, tightly-focused and effective plan that will function on the numbers of personnel, and the time-scales, needed to address the NavLab STEM problem.

Appendix H: Payback Mechanisms

Requiring quid-pro-quo or payback mechanisms is a critical keystone element in addressing too few STEM workers in the NavLabs. As a capture consideration, payback refers to recipients of Navy funding and/or opportunities being required to give back to the Navy their time in exchange. Most especially, payback should occur at every college-degree level.

We are suggesting a more overt plan than anything we have seen in place. The payback mechanisms should take various forms commensurate with what was given and appropriate to the age of recipients. Funds, for example, require a stronger payback than would opportunities.

This concept is nothing new to the Navy (e.g., ROTC, Navy "1800" career-officer program, and the like). Nor is it new elsewhere in America (e.g., various forms of traineeships across the federal government). Navy STEM educational support should be in the form of a convertible loan, repayable either via money (with accrued interest) or, preferably, employment at a NavLab. Extend this concept to include graduate student support whether direct or via Navy-funded research grants to academic PIs. (This type of support should not replace the traditional research proposal that includes an "un-named graduate student" but should be available as an option to the student, perhaps competitively.) This opportunity should include a student option as to where to work (i.e., which NavLab), debt forgiveness on an XX%-per-job-year basis, and other incentives, e.g., further forgiveness for active mentoring of UG Navy-funded STEM students or for helping with local K→12 efforts, or for training counselors and teachers, etc.

All elements of the payback mechanism are not legally enforceable and would be stated as such. Here are some probable scenarios for recipient obligations:

- If tuition funds are extended, recipients in a quid-pro-quo arrangement would sign a **contract** to work at a NavLab.

- If employment, including paid, is extended, recipients would sign a **letter of intent** to consider a civilian Navy career at the end of the employment appointment or when student graduates.

- If an apprenticeship without pay is awarded to learn from a scientist or engineer at a NavLab or a UARC, recipients would sign a **letter of intent** to consider a civilian Navy career at the end of the apprenticeship.

- If an apprenticeship with pay is awarded to learn from a scientist or engineer at a NavLab or a UARC, recipients would sign a **letter of commitment** to consider a civilian Navy career at the end of the apprenticeship or upon graduation.

- If a financial prize is awarded, most likely to K→12 students, a **letter of congratulations**, e.g., "Congratulations, you have received these funds from the U.S. Navy and we hope you will consider a career in the civilian Navy," is sent to recipients and their parents, if appropriate. Such letters should be accompanied with a recruitment brochure that shows the future opportunities and benefits afforded by a civilian Navy career.

- If an apprenticeship with or without pay is awarded, part of the payback could be in the form of mentoring students in K→12 or postdocs **mentoring** UGs in the UARCs, and/or providing **technical expertise** to the development of K→12 materials.

- If an opportunity is extended to K→12 students to come to a summer camp or an event, sponsored in part by a NavLab, or if G10→12 students are given the opportunity to work or apprentice for a summer at a NavLab or a UARC, recipients and their parents would receive a **letter of congratulations**: "Congratulations, you have been extended the opportunity by the U.S. Navy to participate in … and we hope you will consider a career in the civilian Navy." Such letters should be accompanied with a recruitment brochure that shows the future opportunities and benefits afforded by a civilian Navy career.

Recommendation

The Navy has so much to offer it should not be shy about blowing its own horn. What other employer, particularly in today's job market, can offer educational support plus career-long employment with numerous advancement opportunities, not to mention benefits? The Navy would be wise to put **payback mechanisms** in place **now** because today's advantageous ratio of applicants per job won't last forever. Developing a series of letters, one civilian recruitment brochure, and one educational opportunities brochure are not arduous tasks and could and should be accomplished in short order. All Navy (and DoD) E&O programs should be augmented thusly via a top-down, funded mandate.

Appendix I: K→Gray STEM Plan

How might the Navy address the entire K→Gray STEM problem? In effect, the Navy already addresses K→Gray (albeit in a haphazard and non-uniform manner) by working both within the Navy and in conjunction with many and varied national non-Navy STEM efforts. **A major (i.e., complete) lack is: (1) a focus on STEM recruiting within E&O programs that (2) have built-in tracking and payback mechanisms.**

Since we know that someone needs to reach students by G6, and the national effort to date has had little success, it is clearly in the Navy's best interests not to limit its E&O efforts only to colleges and beyond. This is especially obvious given our claim here that the Navy must make a paradigm shift and take a systems approach and long-term view of such problems. Because ROI is especially hard to measure in K→12 efforts, we need to focus Navy efforts on innovative approaches that have the most potential to affect the STEM problem in the early grades. Many innovative "local" NavLab E&O efforts already concentrate strongly on this area: locally-proven good ideas abound and should be studied and exported whenever feasible.

The K→Gray STEM Plan (KGSP) involves developing various partnerships to gain Navy access to contact information for high-scoring K→12 students in STEM disciplines on national education tests, and to use that access to provide information to the students and their parents about Navy STEM careers and Navy STEM financial aid for college studies. This approach can also be bolstered through partnerships with other agencies such as NSF. The KGSP delineates various approaches appropriate to GK→6, G7→9, G10→12 with regard to acquiring contact information from national test results within a Navy Strategic Plan to increase STEM worker-years in NavLabs. KGSP then branches into approaches for UG, PhD, postdoc, faculty, and grays, all of which dovetail with the concept of mandatory payback mechanisms.

KGSP should be implemented in stages via the selection of a couple U.S. cities and at a few targeted schools to "learn" how best to conduct the KGSP before launching nationwide.

(Note: Although elements of the plan are numbered, some elements should be done simultaneously and not necessarily in the order listed.)

Grades K→6

1) Acquire minimalist access (names only) to national education test results in GK→6 and track promising students. This will most likely require forming a partnership with Arne Duncan, U.S. Secretary of Education. Repeat every other year.

2) Target high STEM scorers, particularly minorities and those from low-income areas of the U.S. from whom we can expect the greatest loyalty throughout their careers. The NSB states, "The Federal Government should ensure that we are developing the talents of all children who have the potential to become STEM innovators or excellent STEM professionals." (p. 2)

3) Communicate with parents of high STEM scorers regarding general STEM opportunities and the need for STEMs in the U.S. If there are legal issues or difficulty accessing student scores and their parents, then the Secretary of the Navy would have to work with the U.S. Dept. of Education to get them to be part of the STEM program, which could afford the opportunity to include Navy applications of STEM. Communication avenues could be school assemblies or small meetings at the school, pre-arranged home visits, direct mail, etc.

4) Develop Navy educational toys for smart kids and cool Navy shirts, e.g., T-shirt with pocket emblem and official looking seal on back. Packaging includes promotional statements about serving the country in a family environment with photos showing young men and women, in casual civilian attire doing helpful tasks in various settings. Aggressively market these items and make them widely available over the Internet and in chain stores like Target.

5) Link primarily K→6 to the nation's 300 science and technology centers that offer hands-on, informal education opportunities to experience fun science and technology.

Grades 7→9

1) Track same K→6 students in G7→9 with new test results and add new promising STEM students and track them.

2) Target high STEM scorers, particularly minorities and those from low-income areas of the U.S. from whom we can expect the greatest loyalty throughout their career.

3) Communicate with students and parents of high STEM scorers regarding general STEM opportunities and the need for STEMs in the U.S. If there are legal issues or difficulty accessing student scores and their parents, then the Secretary of the Navy would have to work with the U.S. Dept. of Education to get them to be part of the STEM program, which could afford the opportunity to include Navy applications of STEM. Communication avenues could be school assemblies or small meetings at the school, pre-arranged home visits, direct mail, or a combination of such with follow-up phone calls or emails if parents have shared contact information.

4) Link to the nation's 300 science and technology centers that offer hands-on, informal education opportunities to solve problems through science and technology.

Grades 10→12

1) Track same G7→9 students in G10→12 with new test results and add new promising STEM students and track them.

2) Target high STEM scorers, particularly those from low-income areas of the U.S. from whom we can expect the greatest loyalty throughout their career.

3) Present available Navy scholarship and internship programs to these students and their parents

4) Present Letter of Commitment to these students and their parents with place for signature for those students receiving financial benefits

Undergraduates, Graduates, Postdocs, Faculty

1) Present available Navy financial aid, scholarship and internship programs to these students and faculty clearly on home pages of all NavLab websites

2) Track these students

3) Present jobs and career opportunities clearly on home pages of all NavLab websites

4) Present Letter of Commitment with place for signature for those students receiving financial benefits

Grays

1) Present jobs and career opportunities clearly on home pages of all NavLab websites

2) In all appropriate media, state that the Navy values and needs experienced STEM professionals

3) All NavLab websites need to emphasize career training and re-training opportunities

Note: The Navy's long-term focus needs to be K→Gray to ensure that we prepare for the STEM personnel needs of the future throughout a STEM professional's career. This message of K→Gray has subtle benefits for those choosing to make the Navy their career home. Very few employment opportunities like this exist any more and the Navy should

market that unique message, i.e., lifetime employment with advancement opportunities and benefits.

Appendix J: Humanist STEM Media Plan

"The President and his Administration should emphasize to the general public, early and often, the importance of a solid education, especially in STEM, for all of our students. The need is such that it calls for a **public awareness campaign** similar in scale to those in the past on public health issues (e.g., the food pyramid, physical fitness, anti-smoking, etc.)." (National Science Board, p. 2) We recommend more than public awareness of STEM, rather a more urgent message that draws people into the challenge and the solution in an upbeat way.

A media campaign should be ubiquitous and waged through print, web, promotional items, video, TV, radio, technical society meetings, anywhere potential STEM-qualified personnel and even the general public, i.e., parents of K→12, are likely to bump into it. The faces of the campaign should be those of young STEM professionals.

The Humanist STEM Media Plan (HSMP) for increasing STEM must be:

1) multifaceted (print, promotional items, video, TV, radio, Facebook, and most especially web, the #1 investigative modality of the target audience)

2) populated with young scientists and engineers at work helping people and/or the planet

3) up to date in design

4) simple in content

5) targeted at potential students and employees, not at the Navy itself

6) coherent in all facets

7) consistent in messaging

8) clear as to Navy educational, career, and specific job opportunities

9) subject to central control and direction

10) cross-referenced among individual Navy sites as appropriate

11) "all-Navy" centralized site executed by dedicated and web-savvy staff and resources

HSMP is an outgrowth of three conditions:

1) The widespread need and complex problem of attracting more scientists and engineers into Navy labs

2) The nature of the audience the Navy needs to attract

3) The current lack of a unified message across the Naval enterprise

Our recommendation flows organically from the paradigm shift in thinking we are urging the Navy to undertake. Thus, HSMP is designed as a media campaign featuring profiles of scientists and engineers who are prevalent in print brochures (two: one for recruitment and one for K→Gray educational programs), on TV and radio spots, Facebook, and/or other social networking websites such as Twitter, Flickr, YouTube, and Think MTV, and websites including Navy, ONR, NRL, and all Navy labs including the UARCs.

HSMP should launch with profiles of young engineers and scientists conducting "cool research" at NavLabs. These individuals are primarily about 24 years of age and diverse—black female, white female, Asian female, Hispanic male, Native American male, and one 50-year-old white male. Featuring diverse people at work is not a new idea; precedence at the simplest implementation includes people photos on various Navy websites, and a more sophisticated implementation are the personal stories on the commendable National Defense Education Program's website: **http://www.ndep.us/**. Further, BBMG stresses the need for new faces of engineering to introduce the young already working in the field. (p. 11) The difference with HSMP is its focused message to attract STEM personnel to the Navy labs.

HSMP profiles include:

1) K→12-university schooling

2) Career path

3) Accomplishments

4) When they first became interested in STEM

5) Key STEM influences / mentors

6) Possible STEM programs participated in

7) View of the S&Es' current jobs, i.e., what they do during a typical day

8) The accomplishment(s) of which they are most proud

The HSMP profiles may or may not include an overt appeal to come to work for the Navy, but the implicit message is clear: consideration of a Navy STEM career is a wise choice.

The idea behind this media campaign is to show students and emerging professionals real people who conduct gratifying work for the Navy that in some way helps improve hu-

manity and/or the planet. We know this approach works to attract women into STEM disciplines because of the success at Gonzaga University in Spokane, WA.

Gonzaga University is a PUI with a few masters programs (mostly non-STEM) and no PhD program, but it has an extensive and well-respected undergrad STEM program. They employ a humanistic approach to recruiting students, particularly women, into STEM. They have succeeded spectacularly well: more women wish to get in than are spaces available, and none drop out. GU has a 100% completion (BS) rate so far with N~150.

The program involves intensive faculty and student mentoring of new students, restructuring of the approach within classes to emphasize humanistic concerns, and two full summers of on-the-ground work using their training to solve human problems in Africa. Students know from day one of their freshman year that all summer between freshman and sophomore years they will be working in the real world, and as a result, study really hard. Second-time students (sophomore–junior year summertime) provide intensive peer mentoring to first-year students on the ground in Africa, and also during freshman-year classes. Classes themselves center around hands-on solving of human problems, in teamwork with non-STEM students at other nearby PUIs.

Certainly, we need to take a close look at how, i.e., what methods, Gonzaga deployed when they first began to market to women. How did they get the word out? Even though the Navy's venue is far larger than a PUI's, we may find some applicable ideas.

The Navy's message throughout all HSMP communication, i.e., print, promotion, video, web, TV, radio, etc., should include some version of the following:

1) We need you

2) Endless career opportunities await you

3) Join a NavLab family that cares

4) Serve your country

5) STEM is exciting and rewarding; STEM lets you work on real-world applications that make a difference

The importance of the consistency of this message cannot be over stated. BBMG believes in "ensuring that all communications strategies and tactics are seamlessly integrated to reinforce the same brand message…." (p. 7) And they believe that "any message must be used consistently and creatively as part of a targeted communications program designed to find, reach, motivate and inspire its audiences." (p. 28) These ideas are not new but founded on basic marketing principles.

Sidenotes. "Accelerate your life [through the Navy]" is the message widely used for enlisted personnel; recruitment brochures available upon request. In the interest of consistency of message for the Navy as a whole, we considered appropriating this message for the NavLabs, but decided against it because of the need to differentiate the civilian Navy from the enlisted. This need suggests that we may need to consider developing a civilian Navy logo for this campaign to be used everywhere.

Bottom line. Without a similar feel and message, regardless of the specific content differences, the web, other media, and the E&O programs are akin to a new hire arriving on day one and finding no office, desk, computer, and no one knowing his/her name. Rather the message should be: "We want you. We're ready for you. We've been expecting you. We're glad you're here." The drawback of an uncoordinated message for the Navy is losing STEM people because the information they need is confusing or unavailable. Who has time to figure out how to get hired or how to take advantage of an education program? And why bother with an organization that cannot communicate what they want? Potential employees will give up and go elsewhere to an organization that clearly wants them and is ready for them. Coordinating what's said in print, promotion, video, TV, radio, and the web benefits everyone, particularly the Navy as it costs far less to say the same thing everywhere. What's more, it's memorable.

Appendix K: Website and Activity Report Cards

The following report cards are included herein:

1) NAVSEA

2) NAVAIR

3–6) NSWC: Carderock, Dahlgren, Panama City, Port Hueneme

7) NUWC, Keyport

8–12) SPAWAR: Pacific San Diego; Atlantic: Charleston, New Orleans, Norfolk, SSFA

13) UARC: APL-JHU

14) NDSEG

Note: Printouts of web pages are available upon request, containing comments that support the evaluations presented in the report cards.

ONR Science and Technology E&O Website and Activity Report Card

Purpose: To systematically and quantitatively evaluate current education/outreach/recruitment activities and programs, and associated web presence. This effort will yield a preliminary assessment of both ongoing activities of various DoD and Navy endeavors and the activities' representation on the web; it seeks to identify strengths and deficiencies among all considered sites, as well as natural linkages among the groups under investigation.

Note: Wherever possible we seek to elucidate the difference between **activities** and **corresponding web presence**.

Web Evaluation Categories (Graded A–F)

Audience

Who appears to be the intended audience(s) or user(s) of this site (i.e., students, potential employees, community members)? Does the site communicate effectively with the presumed target audience(s)? Does the site answer probable questions these users might have regarding the presented information?

Diversity

Does the site express in visuals and text that the organization welcomes or is responsive to the specific interests of people of diverse race and gender?

Content

Does the site represent the following and how extensive is the information?

1) Education

2) Outreach / Community Relations

3) Careers / Recruitment

Activities

What are the education and outreach activities currently being pursued by this entity? What **age group** participates in these activities? Is there **evidence of linkages** between these education and outreach activities **and local/regional schools**? What are they? Is there evidence of linkages between these education and outreach activities **and other Navy entities**? What are they? Are there natural linkages to other website programs or opportunities that are **not** explicit, but could be made so?

Presentation

Does the site appear to be of the 21st century? Specifically, is the presentation current and relevant? Is the presentation visually engaging for the intended audience(s)?

Navigation

How well integrated is the site content? Is it clear how to find various types of information? Can users always return to where they were? Is the navigation structure obvious? Is it likely users can return to the site at a later time and quickly find the information they previously found?

Message

Does the site express an interest in wanting S&Es to come to work for that organization? Does the site make a connection to the Navy and/or ONR? Does the message include the advantages and opportunities afforded STEM students or potential employees when they work for the organization and/or are associated with the Navy?

Follow-up

Are there opportunities for user follow-up? Is the follow-up active, i.e., users register to receive more information and the site contacts them, or is it passive, i.e., users are presented with links for their own investigation.

NAVSEA

Date evaluated: September 2008 and 23 April 2009

Audience   **D**

Diversity   **D**

no visuals with people, only ships; exception: leadership but they're all mature white males; however, a video posted on Home (23 April 2009) showed a couple women.

Content   **D**

Activities   **C**

Presentation   **C**

Navigation   **C–**

Message   **D**

Follow-up   **D**

passive with email address

Who appears to be the targeted audience(s)?

Hard to say

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

N

How effectively is this website addressing the targeted audience?

Not effective

Current education and outreach activities

Naval Acquisition Intern Program (NAIP) trains promising young college graduates in the field of naval acquisition.

Target age/educational group for these activities

Probably BS graduates just out of school

Evidence of education/outreach linkages to local/regional schools

NA

Evidence of education/outreach linkages to other Navy ventures

NA

Comments

Unfortunately, a Google search on NAVSEA, yeilds as its 2nd listing

http://www.globalsecurity.org/military/agency/navy/navsea.htm

which is an in-depth history justified thusly: "The current organization of the Department of the Navy is the result of an evolutionary process. Since the Naval Sea Systems Command is a product of this process, a sketch of the major steps in the evolution is appropriate."

However, the home page in September 2008 had an inviting quotation, personalized, from the Vice Admiral with his photo; download icons for the Strategic Business Plan and OnWatch publications; plus continually updated press releases. And, by 23 April 2009, NAVSEA had redesigned the home page, adding nice left column menu buttons, including "Leadership," and subheads, plus a promotional video. Still, though, at the top of the page is a stuffy mission statement not written for the web or an audience. No mention of needing S&Es.

"About NAVSEA" is no longer devoted to Leadership (now under its own button) but still has NAVSEA 101 that has small text running the full horizontal width of the page that emphasizes how large the organization is, its budget, etc. The Fact File is now under a subhead, which reads Fact Sheets, and is still a listing of aircraft, ships, etc. without explanation or introduction, or any "sheets."

Under the menu button, "Careers" is a subhead, "NAVSEA Jobs" with URLs to go elsewhere to find them. The following text is good:

"The Department of the Navy is more than ships, aircraft and sailors — it is more than 176,000 civilian employees at Navy and Marine Corps commands, bases, stations and facilities throughout the United States and around the world.

Naval Sea Systems command employs a highly trained, educated and skilled workforce to support today's sophisticated Navy and Marine Corps ships, aircraft, weapon systems and computer systems."

In September 2008, under "Careers" were FAQs, under which was Naval Acquisition Intern Program (NAIP) that trains promising young college graduates in the field of naval acquisition. This is a full-time PAID position and it was hidden (ouch) under FAQs. But, by 23 April 2009, NAIP warranted its own subhead. Hooray!

NAVAIR, Pax River

http://www.navair.navy.mil
Date evaluated: 24–25 February 2009 and 2 April 2009

Audience   **B**

Diversity   **B**

Content   **B-**

Activities   **B**

Presentation   **B-**

Relatively contemporary, particularly "Jobs"

Navigation   **C+**

Hidden Education programs

Message   **B**

Clear

Follow-up   **C**

Passive but allows for posting resumés, which is great

Who appears to be the targeted audience(s)?

College age on "Jobs" button. There's a whiff of future employees in mind in the use of language as well as great pride in NAVAIR's mission. But many times NAVAIR is talking to itself. They even use globs of written text inappropriate for the web.

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

Y

How effectively is this website addressing the targeted audience?

Does a good job addressing college age youth on "Jobs" section. The "Gallery" button header is brilliant: "Picture Yourself" which is coupled with numerous photos of youth working. Direct and appealing. The bad news is that by 2 April 2009 that header and people pix were unavailable, not working. The only available gallery was on the main NAVAIR site populated by numerous helicopter shots.

Current education and outreach activities

None indicated on website unless users delve into NAWCWD Hiring Programs: Interns / Co-ops = SEEP, SCEP, STEP; Prospective and Recent Grads; and Experienced Professionals, a good range of programs. But on 2 April 2009, this user couldn't find these.

Nothing for K➔12 and no community involvement.

Target age/educational group for these activities

College age primarily

Evidence of education/outreach linkages to local/regional schools

No

Evidence of education/outreach linkages to other Navy ventures

No

Comments

The home page is not a recruiting tool as it could and should be, although it does have an intriguing button embedded on the NAWCWD pp: "Exciting Jobs." But these pages were no longer available on 2 April 2009.

The NAVAIR home "Jobs" button leads to a choice of two links, one is a cool, separate-appearing site designed for college kids. The NAVAIR jobs site is contemporary and targeted, but there are two problems:

The recruitment message is seven clicks / buttons down from the NAVAIR "Jobs" home and it states NAVAIR is "actively" hiring. This should be on the home page as well and be truly active.

Banners on all these pages change from page to page and do not maintain the NAVAIR identity, i.e., the home page doesn't look like any of the other pages; even the logo changes color and placement on the page. In fact, NAVAIR "Jobs" home doesn't even have a NAVAIR logo.

The other link goes to a NAVAIR Human Resources Department site that does not look like anything else anywhere on the NAVAIR site. Has the logo but uses it unlike anywhere on the main site, changes it entirely.

Clicking "Slating Panel" sends users off to a written text document and the left column buttons are no longer available.

NSWC Carderock Division

http://www.dt.navy.mil/

Date evaluated: 30 September 2008

Audience **B+**

Home page invites civilian S&Es.

Diversity **B**

Stated in text and visuals.

Content **B**

This grade would be higher if E&O were called out and prominent.

Activities **A**

Presentation **B–**

Content / Activities kept this grade high despite inconsistencies in approach and the thoroughly dull "About Us" and "Our Capabilities" pages versus the better looking "Working With Us" and "Employment" pages, which use some photos but the voice is indirect and the best messages are crammed and hidden at paragraph ends.

Navigation **A**

Message **A–**

Follow-up **C+**

Mostly passive

Who appears to be the targeted audience(s)?

Civilian S&Es, potential employees

Are answers provided to probable and relevant questions for the targeted audience(s)? (y/n)

For the most part, yes.

How effectively is this website addressing the targeted audience?

Pretty well. Directly solicits new employees, particularly civilian S&Es. However, the voice used on the website to address its audience is more often than not dull, factual, boring, and inappropriate for the web. Sentences should be shorter and text not laid out in large blocks that are hard to read.

Current education and outreach activities

- Scientist / Engineer Development Program

- College Recruitment Schedule

- SEAP

- Student Volunteer Program

- Student Educational Employment Program, Student Career Experience Program (COOP)

These appear to be great programs but are buried at the bottom of "Employment" and deserve their own section.

Target age/educational group for these activities

- Scientist / Engineer Development Program, new civilian employees

- College Recruitment Schedule, college students

- SEAP, high school and college students

- Student Volunteer Program, high school

- Student Educational Employment Program, i.e., Student Career Experience Program (COOP), apparently college age although it doesn't specifically say so.

Evidence of education/outreach linkages to local/regional schools

No evidence other than stating they work with high schools; no examples, pictures, etc.

Evidence of education/outreach linkages to other Navy ventures

Links are provided to other surface warfare centers and to undersea warfare centers but there's no evidence of linkages to other Navy ventures. SEAP, for example, appears only to be within Carderock and not an entity of ONR, and there's no indication of how to apply.

Comments

Carderock has a number of areas of which it can be proud and hail to its advantage: Over one dozen strategic partnerships with institutions of higher learning and an accompanying entry-level Scientist / Engineer Development Program; great outreach activities; and beautiful printed pieces, e.g., SEAFRAME magazine and the Carderock brochure, which are rightly featured on the home page. These printed pieces are very well written and illustrated. They've a story to tell and are written with a sense of audience. These pieces make it clear that Carderock knows how to market. For the most part this direct approach to users, although better than on some NSWC websites, is missing on the Carderock website and it should not be. The voice should be the same in printed and web media.

NSWC, Dahlgren

http://www.nswc.navy.mil/
Date evaluated: 8 October 2008

Audience   B+

Sometimes this site is just talking to itself.

Diversity   B

Content   A–

Education should be called out separately and not lumped under "Careers" that then is called "Recruiting," "Jobs," and/or "Employment." Better yet, leave the student programs where they are and duplicate them in an education section.

Activities   A+

Presentation   B–

Content helped keep this grade high despite the excess text and too little visual interest on many pages.

Navigation   F

Confusing, inconsistent terminology and button structure. Difficult to know where you are and how to return to where you were.

Message   A

Dalhgren is telling a story and that's always a good strategy as a story is memorable, interesting. Consistent throughout but sabotaged by poor navigational structure.

Follow-up   B–

Passive, but excellent appeal and desire to answer student questions.

Who appears to be the targeted audience(s)?

New S&E employees.

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

Yes, and does good job of giving potential S&Es local information.

How effectively is this website addressing the targeted audience?

Very well except for confusing terminology and navigation problems.

Current Education and outreach activities

SCEP (COOP), STEP, SMART, NREIP, SEAP, WRP (disabilities), and they're involved in 21CEETP, which is only mentioned under "Press Room" as a VDP event, 19 August 2008.

Target age/educational group for these activities

Under "Careers" text states activities are for high school and up. 21CEETP, though, is middle school and up.

Evidence of education/outreach linkages to local/regional schools

No evidence; good programs but only described with text in general terms with the noted exception of 21CEETP mentioned above.

Evidence of education/outreach linkages to other Navy ventures

No evidence of linkages to E&O, but does have links to other Navy entities.

Comments

The message to S&Es is straightforward, huge, and up front on the home page. This is excellent and unique among warfare centers. Further, the messaging to S&Es runs throughout the site and is reinforced by the welcoming and positive approach Dahlgren takes toward their mission. For the most part Dahlgren has a strong sense of audience and they're telling a story they're rightfully proud of.

E&O activities are strong and numerous but they need to show these with photos of the events under way, students participating, receiving awards, etc. A separate Education section needs to be developed and not bury activities under "Careers" that then is called "Recruiting," "Jobs," and/or "Employment." This terminology needs to be standardized, preferably stick with "Careers" and "Education" because these better support the mission to attract S&Es to a career, a home for many endeavors upon which they could embark.

Further, the term "Recruitment" or "Recruiting" is an inside military term and not from the point of view of those using the website.

Navigation buttons are confusing and inconsistent. "About Us" is also used within sections in addition to it being about Dahlgren in the top menu bar. The term "Links" is overused, sometimes separately, sometimes as "Internal" and sometimes "External." Links are constantly changing from one page to the next also adding to the confusion. Links should only refer to external and anything internal to the site should just have its live title in the same menu section throughout the site. Some internal links when clicked throw the user clear out of the site and there's no "Back" button available. This is a complex website that is content rich. A bit of reprogramming and content revision would make it very useable.

NSWC Panama City Division

Date evaluated: 30 September 2008

Audience   D+

Dull, indirect messaging

Diversity   E

No evidence of diversity except well into the action video on home page

Content   B

Because this is a complete website

Activities   A–

Although hidden under "Community" there are three great programs

Presentation   A- (home page) C- (rest of the site)

Navigation   B

Users can adequately get around but awkward sandwiching of info; see home page notes

Message   B–

"Employment, Typical Work Assignments" acknowledges need for S&Es but that's the only place. Otherwise PCD is talking to itself, covering its bases and not thinking about its future workforce of S&Es.

Follow-up   C

Clickable info lines that go to email

Who appears to be the targeted audience(s)?

Panama City Division, sometimes potential employees, and entrepreneurial organizations that have dual-use visions

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

Sometimes

How effectively is this website addressing the targeted audience?

Not well because the messages are often dull statements of fact without awareness of an actual person who may be reading and looking for information

Current education and outreach activities

Three Rivers Science and Engineering Fair, Summer Student Program, and Children's Christmas Party

Target age/educational group for these activities

- Three Rivers Science and Engineering Fair – (established 1986) apparently directed toward high school juniors and seniors.

- Summer Student Program – Gould Science Award (established 1974) given to one graduating senior from each of three local high schools

- Children's Christmas Party – (established 1950) 100 underprivileged children in Bay County

Evidence of education/outreach linkages to local/regional schools

Evidence is only stated in paragraphs on each of these programs; no pictures or voices of recipients. It's a shame since these are long standing, apparently excellent programs. Children's Party has even won awards.

Evidence of education/outreach linkages to other Navy ventures

None

Comments

Adequate categories included, some great outreach and education activities, a good looking home page with dynamic photo display, but the rest of the site is text.

There's a smattering of thumbnail photos on the "About Us, Summary" page but they're not clickable and the labels don't mimic the mission and system areas on the left navigation panel. In fact, some of them don't even coincide, e.g., "Coastal Operations" and

"Joint Operability." "Where do I go for explanations of these?" a disgruntled user could ask.

The good stuff, the things PCD could use to draw in the work force of tomorrow is hidden such as natural and cultural resource awards and commendations. These are only found under "Environment, Public Outreach."

NSWC Port Hueneme

www.phdnswc.navy.mil
Date evaluated: 11 September 2008

Audience   B-

Diversity   C–

No mention of diversity but shows photo of white kids, mostly girls, winning competition

Content   B–

Missing Navy message, particularly under "Careers," and missing mention of great O&E activities on all pages except buried under button "Community." Community page keeps this grade high.

Activities   A+

Presentation   B–

Community page keeps this grade high.

Navigation   B

Message   B–

Community page keeps this grade high.

Follow-up   C

Passive

Who appears to be the targeted audience(s)?

Most of this site has no audience. Only on Community page is there an audience: small business, community groups, and K→12 students.

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

No, site is thin on info.

How effectively is this website addressing the targeted audience?

Fine on the Community page but doesn't often directly address that triple audience. Could be stronger. Otherwise, they're talking to themselves; home page is dreadful. Needs a more direct approach throughout particularly with recruitment of new S&Es, which is non-existent.

Current education and outreach activities

Navy Gold Coast Annual Small Business Conference; Ship tours; Blood drives; Employee giving to needy; Equipment donations to schools; Student pre-engineering program; Natl. Engineer's Week Competition for middle schools.

Target age/educational group for these activities

Local K→12 and adults

Evidence of education/outreach linkages to local/regional schools

Yes, Las Colinas Middle School as one winner of Natl. Engineer's Week Competition—actual photograph. Other activity—pre-engineering program—is explained in text.

Evidence of education/outreach linkages to other Navy ventures

No

Comments

Site is really mixed; great activities; excitement about industry, outreach, and educational partnerships, and as such, for the most part, directly addresses these audiences on the Community page.

Ho-hum about recruitment; the only reason to come to work at PHD is "exciting locations." No Navy message anywhere and no invitation to make PHD your career home.

Navy.mil and Navy NewsStand site(s) feature PHD with great info (see attached print outs) but this is not on the PHD site

NOTE: As of 11 September 2008, the PHD site has been down for three days, so couldn't check out "News" and "Links" that I didn't print off earlier. Talked to PHD twice yesterday and they haven't been able to fix their site.

NUWC Keyport

http://www.nuwc.navy.mil/
Dates evaluated: 3, 6–7, 10, and 13 October 2008

Audience   C–

"Community Support" page kept this grade higher than without the activities.

Diversity   D

Content   C

Activities   B

No mention of SEAPerch, however.

Presentation   C–

Crude, outmoded style; some text in columns with visuals helped grade not go any lower

Navigation   F

Difficult and confusing; finding Keyport among NSWC website is not easy and accessing home page is nearly impossible. Hard to remember how to do it a second or third time.

Message   C

Positive, up-tempo tone is nice here and there but the website neither invites S&Es to come to work nor students to participate in activities.

Follow-up   C–

Passive

Who appears to be the targeted audience(s)?

Mixed. Says "Engineers Wanted" on Newport page but doesn't address them. Mostly talking to themselves. They should welcome students and S&Es and talk up Keyport.

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

No

How effectively is this website addressing the targeted audience?

Not at all

Current education and outreach activities

- Cooperative Education Program with local high schools, i.e., local science fairs and classroom discussions.

- Naval Undersea Museum Foundation Science Education Alliance

- Scholarship Foundation (SF): $1,000 and E.H. Lesinski $1,500. SF established in 1987 and has awarded $70,500 total. Funds raised through bake sales, fun runs, and other activities.

- Bremerton Armed Forces Festival

- Lighted boat parades and Christmas cruise

Target age/educational group for these activities

Scholarships are for high school and museum programs for all ages.

Evidence of education/outreach linkages to local/regional schools

Statements in text but no specific schools and no visual evidence.

Evidence of education/outreach linkages to other Navy ventures

No E&O but links under "Library" button to other Navy sites.

Comments

The look and feel of the Keyport website is crude and antiquated. Education is hidden under "Community Support." SEAPerch is absent and any mention of Keyport on the SEAPerch site is also absent.

Combining both undersea warfare centers does not work well, although if done right, it could work nicely. As it is, the navigation even to the site is confusing and downplays Keyport. Either it's not mentioned or not even highlighted in blocks of endless text. And then during the slog through the Keyport site Newport comes up for "History" and the like with no mention of Keyport at all.

However, the Keyport Mission, Vision, and Technical Leadership Areas use bullets of text and columns and chunks of text along with photos to increase the readability. And the tone and liveliness of the text is positive and not boring.

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SPAWAR San Diego

http://enterprise.spawar.navy.mil/
Date evaluated: 4 November 2008

Audience   C–

Little sense of audience

Diversity   B–

Shows women and people of color on "Educational Outreach" and the "News" pages

Content   B

A lot of content and good programs kept grade high

Activities   A

Excellent E&O and HR programs at all levels

Presentation D

Text with few visuals

Navigation   C

Okay for SSCSD but some confusion; needs site map

Message   C+

Full of jargon and talking to themselves

Follow-up   D+

Extremely passive

Who appears to be the targeted audience(s)?

To some degree new employees on HR page but otherwise talking to themselves

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

No

How effectively is this website addressing the targeted audience?

Not well

Current education and outreach activities

HR Programs—Student Temporary Employment Program (STEP), Student Career Experience Program (SCEP), New Professional Program (NP) mainly for computer scientists

E&O Programs—Math, Engineering, and Science Achievement (MESA); SD Unified School District College, Career, and Technical Education (CCTE); Science, Mathematics, and Research for Transformation (SMART) Defense Scholarship for Service Program; Science and Engineering Apprentice Program (SEAP); Naval Research Enterprise Intern Program (NREIP)

Target age/educational group for these activities

K→College and new professional

Evidence of education/outreach linkages to local/regional schools

Yes, with photos under "Educational Outreach," "Past Events"

Evidence of education/outreach linkages to other Navy ventures

Navy ventures — only with other SPAWAR locations but it's not an intentional strategy. Outside Navy links are under "Educational Outreach"

Comments

Excellent K→College and New Professional programs. The NP Program is a link to an exclusive website developed by the young professionals themselves, so it appeals to them with a strong sense of audience. The NP site is fairly well done and includes why you'd want to work for SSCSD, which is good, and FAQs.

SSCSD has a relatively complex website with a lot of content. A sitemap could help because it's hard to navigate; can't always tell where you've been. The grades included here are for this site and exclude the NP site. Essentially, the SSCSD site is written text slapped onto the web. There's no appeal to potential employees let alone S&Es. Even under HR it's just the facts, no invitation other than the word "Welcome." Very poor sense of audience, which is a great shame, since SSCSD is hiding terrific programs. A different approach on the home page could help this problem.

Notes on SPAWAR sites in general and the consolidation of website presence

In researching SPAWAR centers, if you Google "SPAWAR New Orleans" and click here: SPAWAR Systems Center New Orleans (SSCNOLA), This is the url: **http://enterprise.spawar.navy.mil/body.cfm?Type=C&category=18&subcat=59**

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If you key in "SPAWAR, Charleston," you get a Google entry for SPAWAR but only articles that refer to Charleston.

"SPAWAR Norfolk," however, has its own site but is not listed in the left column as a field activity.

If you click "SSC Atlantic" you get upper right buttons for Charleston, New Orleans, and Norfolk. Only then can you click Charleston and New Orleans and get there.

Field Activities

In general, the field activities need a clearer connection to SPAWAR San Diego and vice versa. The navigation needs to be consistent throughout all SPAWAR sites. Menus should not vanish with new ones replacing the previous page and confusing users as to how they arrived where they currently are on the site. The issue of new employees and the need for S&Es should be mentioned on each sites' home pages where it needs to be clear that San Diego handles general info for all the field activities. The home pages of all field activities, in turn, need to refer users to San Diego for general info on E&O activities, career opportunities, employment, etc., but the messages need to be friendly and indicate that each office is interested in new people and in answering their questions.

SPAWAR Charleston

http://enterprise.spawar.navy.mil/body.cfm?type=c&category=32&subcat=72

Date evaluated: 5 November 2008

Audience   *B–*

Lacks direct language to users; "Jobs" page kept grade high

Diversity   *C–*

One black male

Content   *B*

Activities   *B–*

Presentation   *D–*

Mostly text

Navigation   *C*

Difficult to know where user is and how arrived there because the right column buttons change all the time

Message   *B–*

Grade high because of "Jobs" page detailed messaging but language is a distant third person

Follow-up

Very passive

Who appears to be the targeted audience(s)?

Sometimes S&Es—"Jobs" page attempts to address them—but not a concerted effort to talk to an audience

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

No

How effectively is this website addressing the targeted audience?

Not well

Current education and outreach activities

Student Education Employment Program (SEEP), Student Temporary Employment Program (STEP), Student Career Experience Program (SCEP), Navy Acquisition Intern Program (AIP) for college graduates, and Business Education Partnership with Hanahan Middle School (evidently businesses are part of this program but there is only an explanation of this program in text; no evidence in visuals or list of businesses)

Target age/educational group for these activities

- K→College and new professional

- SEEP, STEP, SCEP – College

- One middle school

Evidence of education/outreach linkages to local/regional schools

Hanahan Middle School—in text only. No visuals or list of business partners, etc. to prove it is a viable program. Clicking the Hanahan's live icon takes you to a school district. After considerable hunting and finding the middle school, there's no mention of SPAWAR.

Evidence of education/outreach linkages to other Navy ventures

None, except mention of other SPAWAR locations

Comments

"Jobs" page – although not a direct appeal to S&Es, there's excellent detailed messaging about what's great about SPAWAR Charleston and how well they treat their employees.

New Professional (NP) Program – good use of Q&A. Audience is mixed here as there's a puzzling detailed list of duties for lower level and/or administrative personnel in addition to the sorts of activities expected of a scientist or engineer. Perhaps S&Es are expected to do a combination of these things?

Generally, Charleston is more interested in talking about themselves than in attracting S&Es. This is mostly a matter of not knowing how to address an audience, e.g., "New engineers and scientists are teamed with seasoned workers who can show them the ropes," written in an active rather than the former passive voice: "As a new engineer or scientist you'll be teamed with seasoned workers who'll show you the ropes." The latter is much friendlier and inviting.

Notes on SPAWAR sites in general and the consolidation of website presence

In researching SPAWAR centers, if you Google "SPAWAR New Orleans" and click here: SPAWAR Systems Center New Orleans (SSCNOLA), This is the url: **http://enterprise.spawar.navy.mil/body.cfm?Type=C&category=18&subcat=59**

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SPAWAR New Orleans

http://enterprise.spawar.navy.mil/body.cfm?type=c&category=31&subcat=115
Date evaluated: 6 November 2008 and 19 December 2008 and 29 April 2009

Audience   F

Diversity   F

Content   F

Activities   F

Presentation F

Navigation   D

Message   D

Follow-up   D+

Passive

Who appears to be the targeted audience(s)?

Doesn't appear to be an audience. No mention of the need for S&Es or for employees in general.

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

No

How effectively is this website addressing the targeted audience?

Not well. The only place on the site where they address an audience, i.e., talk to someone and establish their own voice is at the bottom of the "History" page: "The mission … all right here in New Orleans."

Current education and outreach activities

None

Target age/educational group for these activities

None

Evidence of education/outreach linkages to local/regional schools

None

Evidence of education/outreach linkages to other Navy ventures

None

Comments

New Orleans needs a new home page and the page should come up as soon as the site comes up. Users should not have to click on "Home."

With noted exception above under targeted audience, the site addresses no one in particular, not even on "Job Opportunities."

"About SSC Atlantic New Orleans Office"

After reading this section several times it's unclear what NO does, but whatever it is they're doing it more efficiently. Any uninitiated user who is looking for information would be disappointed. The language used is obtuse and written to managers within the organization. Paragraphing would aid readability as would columns of text. [Note: As of 29 April 2009, the home page has been improved a bit with paragraphing.] Most of all this section needs to address potential employees or interested high school students and say why NO is providing technology solutions and for whom they're providing them. Examples of such are necessary and could be drawn from products and the vision statement.

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SPAWAR Norfolk, VA

http://enterprise.spawar.navy.mil/body.cfm?type=c&category=30&subcat=64

Date evaluated: 19 December 2008

Audience   **F**

Diversity   **F**

Content   **F**

Activities   **F**

Presentation **F**

Navigation   **D**

Message   **F**

Follow-up   **F**

Who appears to be the targeted audience(s)?

No apparent audience

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

No

How effectively is this website addressing the targeted audience?

Not at all well since it's unclear who they're addressing.

Current education and outreach activities

None

Target age/educational group for these activities

NA

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Evidence of education/outreach linkages to local/regional schools

NA

Evidence of education/outreach linkages to other Navy ventures

None

Comments

Impressive list of products but why they're developing them and who is using them is missing.

Navigation: Users should not lose the "Norfolk Pages" menu buttons when they go to "Products." Users should always know where they are on a site.

Site lacks an "About Norfolk" section; also lacks mention of where Norfolk is located. Much of the info on the "SSC Atlantic Code 544 Products and Services" belongs in an "About Norfolk" section. This info needs to be written to a user of the site who might be interested in employment and/or a high school student. Is it important to refer to the code number in such general information? Would it not be friendlier to use Norfolk instead?

No mention on any of these pages about E&O or needing employees, let alone wanting S&Es and there should be.

Citrix/Knowledge Center has a paragraph, "Internet Explorer Users," that oddly switches to instructional mode and uses "you" while addressing some unknown audience. This is a problem that should be corrected or removed.

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SPAWAR Space Field Activity (SSFA)

http://enterprise.spawar.navy.mil/body.cfm?Type=C&category=37&subcat=89

Date evaluated: 19 December 2008

Audience **F**

Diversity **F**

Content **F**

Activities **F**

Presentation **F**

 Navigation **D**

Message **F**

Follow-up **F**

Who appears to be the targeted audience(s)?

No apparent audience

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

No

How effectively is this website addressing the targeted audience?

Not at all well since it's unclear who they're addressing—more than likely just themselves. Perhaps there's a requirement or at least an expectation of having a web presence but what's its purpose. None that's apparent.

Current Education and Outreach Activities

None

Target age/educational group for these activities

NA

Evidence of education/outreach linkages to local/regional schools

NA

Evidence of education/outreach linkages to other Navy ventures

None

Comments

Site lacks an "About SSFA" section; also lacks mention of where SSFA is located. "Mission" is a menu button but it goes to a ppt. file. There's a 2005 Strategic Plan and "Visitor Info" button that does show a Chantilly, VA address. All of these files throw the user off the website and require hunting for information that should be readily available.

Navigation: Users should not lose the "SSFA Pages" menu buttons when they go to these document files. Users should always know where they are on a site.

Further, there are a series of bios of commanding officers that users can plow through for information but why should they have to do so?

No mention on any of these pages about E&O or needing employees, let alone wanting S&Es, and there should be.

Notes on SPAWAR sites in general and the consolidation of website presence

In researching SPAWAR centers, if you Google "SPAWAR New Orleans" and click here: SPAWAR Systems Center New Orleans (SSCNOLA), This is the url: **http://enterprise.spawar.navy.mil/body.cfm?Type=C&category=18&subcat=59**

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Applied Physics Laboratory, The Johns Hopkins University, APL-JHU

http://www.jhuapl.edu/
Date evaluated: 23 March 2009

Audience   *A*

Diversity   *A*

Content   *A*

Activities   *A*

Presentation   A

Navigation   **B**

A few times users could be confused as to how they arrived at a page; sometimes thrown out of the site.

Message   *A*

Upbeat

Follow-up   *A–*

Active, with weekly email notices available to prospective employees.

Who appears to be the targeted audience(s)?

Prospective employees

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

Yes

How effectively is this website addressing the targeted audience?

Very well because common language is used and directed at outside users.

Current education and outreach activities

Middle school through college programs and activities

Target age/educational group for these activities

Middle school through college

Evidence of education/outreach linkages to local/regional schools

Yes, via photos besides text

Evidence of education/outreach linkages to other Navy ventures

No

Comments

The web is obviously a priority for APL-JHU. Probably executed by a group of developers, including content developers, who know what they're doing.

Unfortunately, users are thrown out of the site when applying for jobs.

National Defense Science and Engineering Graduate Fellowship

https://www.asee.org/ndseg/

Date evaluated: 11 September 2008

Audience   *A*

Diversity   *A*

Content   *A- (Grade based on purpose of site only and not on E&O)*

Activities   *NA*

Presentation *B*

Dull; paragraphs of text, no visual relief but nice use of bold for readability; unclear ASEE connection

Navigation   *B–*

"Apply Online" appears to throw user out of site because the site's identity vanishes

Message   *B–*

Misses opportunity for Army / Air Force / Navy connection

Follow-up   *A*

Active and passive

Who appears to be the targeted audience(s)?

 Single audience: graduate students

Are answers provided to probable and relevant questions for the targeted audience(s)?(y/n)

Yes

How effectively is this website addressing the targeted audience?

Very well, but some younger students may not know acronyms and those should be defined, particularly if we think in terms of partnering with middle and high schools in some way.

Current education and outreach activities

Fellowship competition is NDSEG's only purpose.

Target age/educational group for these activities

Perhaps 21–30. Students can be just entering graduate school or changing their major or entire field after already being in graduate school. Cannot already have a graduate degree and apply.

Evidence of education/outreach linkages to local/regional schools

NA, because this site's purpose is to present a graduate fellowship competition. However, NDSEG could be encouraged to address middle and high school students who might anticipate such an opportunity in their future and want to know what's involved in getting such an award.

Evidence of education/outreach linkages to other Navy ventures

None, but connection to ASEE and ASEE's message should be clear on home page and elsewhere. Also, site should mention BAA and the Army, Navy, and Air Force connection should be clear on home page.

Comments

This is not a complicated site; there's only a single audience and the information is straightforward. Thus the task is not difficult. However, NDSEG has made it look easy because the info is so clearly written, directed to the specific audience, and it anticipates questions very well.

Site needs to update deadlines everywhere on the site not just on top of the home page.

Appendix L: Plan for UARCs

Maximize Use of UARCs

The Navy must expand and nurture its already close ties with research academia (e.g., the University Applied Research Centers or UARCs) and the academic institutions and processes that produce STEM bachelors, masters, and PhD degree earners. Without new aggressive programs to attract and keep top STEM professionals, the Navy cannot hope to solve tomorrow's next generation weapon systems, workable energy solutions, or the country's economy. Our consideration of the UARCs covers UG→Postdocs.

UARCs are a unique educational asset particularly at the advanced-degree levels, but also for UGs. They are particularly good at (1) divining long-term future trends in science and technology, hence future Navy needs for advanced-degree STEM leadership personnel, (2) doing Navy-relevant R&D, and (3) spinning off STEM-related people into non Nav-Lab but Navy-critical positions in industry and academia. UARCs have multiple roles in supplying overall Navy needs for STEM-trained people (including resupplying the UARCs themselves). UARCs are in a unique position to independently evaluate and respond to Navy needs for advanced-level STEM personnel. They should be given the freedom and dedicated resources to support UGs, graduate students, and postdocs of their choice, choosing students and projects on what the UARCs independently think are Navy-relevant. UARC faculty and graduate students should be actively recruited as technical experts to participate in various items in this Strategic Plan: on-campus mentoring, technical leads in the development of K→12 educational materials, identification and recruitment of STEM-oriented UGs, finding summertime NavLab projects for eligible students, and the like. Each UARC should be given the equivalent of 'block funding' to support (say) five years of postdoc efforts annually, plus resources to support some specified number of UGs, specifically on Navy-relevant work, with an eye to recruiting them into further involvement at NavLabs.

Plan for UARCs

David Sivillo, Deputy Director UARC Laboratory Management Office, in a 20 August 2008 brief at the NAVSEA Recruitment Summit presented, "Graduates Ready For Tasking," a plan for preparing new hires for accelerated career development. This plan would be executed during students' academic careers by providing foundational skills, e.g., military protocol, mission awareness, strategic Navy vision, etc., plus short courses in topics such as sonar systems, hydrodynamics, coatings technology, for example. Our proposal for the UARCs would further Sivillo's vision, and with payback mechanisms in play, bear upon increasing STEM personnel at NavLabs (not to mention retaining them in the future).

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The Navy needs to require that all UARCs acquire and maintain data on students work and degrees associated with the UARCs, on those STEM positions that are available and those filled, and on the number of undergraduate and graduate students, and postdocs engaged in their institutions.

Developing an APL-UW (UARC) Database

It has proven extremely difficult to get data that bear on the success or "return on investment" (ROI) of various educational programs in which the Navy participates. Even were such elementary data as "number of people contacted" available, they would not necessarily bear any relationship to the actual problem being addressed, namely more STEM worker-years in the NavLabs. We have, therefore, undertaken an internal examination of APL-UW records, assuming that the educational process here is in many senses a microcosm of the overall Navy effort on STEM above the K→12 level. APL-UW can serve "*in loco* NavLab," as a surrogate NavLab, because many of the STEM "attractors" and problems researched at APL-UW resemble those at NavLabs. APL-UW is also [simultaneously] effectively a STEM university: it brings in and funds undergraduate and graduate students, and postdoctoral students using a variety of monies (USN, DoD, Army, Air Force, NASA, NSF, NIH, industry, work-study) and does this in many ways (scholarships, as RAs on grant proposals, as PDs, through REU programs, ASERTs, simple student employment).

We are just completing an initial list of all STEM degrees granted via APL-UW since 1989: it is a non-trivial but doable task to identify those students' topical areas, whether they had USN or other DoD support as students, and where they went upon graduation. (We hope to extend this to the other UARCs shortly.) It may be both possible and worthwhile to discover the actual amount of support received. If we are then able to track the students (via their major professors) to their employment, we will be able to study the size of any effect, and to roughly estimate the cost-effectiveness (albeit on small scales) of Navy funding on NavLab employment (e.g., total program cost divided by lab worker-years).

Preliminary APL-UW Results

Although this may certainly change as the work progresses, out of 154 masters and doctorates granted by UW in part for work done at APL-UW (1998–2007 inclusive), to date we have not identified ANY individual who went from APL-UW into a NavLab. This may not be all that surprising since no requirement for NavLab employment was part of the programs in which students participated, nor is there any program or effort to suggest NavLabs as a career option upon graduation. However, a good many APL-UW graduates are now employed at APL-UW itself, which is presumably an indirect benefit to the Naval research enterprise. Several have become STEM university faculty elsewhere (an-

other probable indirect benefit), and others have gone into defense-related industries such as Boeing (yet another probable indirect benefit). **Data such as these are critical to design a strategic plan (e.g., to deciding what existing elements might be kept, modified, or discarded, and what new elements need to be designed), and especially to implement the plan.**

ROI???

The results implied by those early data are disturbing. For example, although these preliminary data contain no specifics about USN funding for the graduates, we do know that many students were supported by funds from a variety of sources traceable to the Navy. Hence, if the observed "no new net worker-year at the labs" holds true, then the return on investment is ZERO (relative to the problem of "more STEM employee-years at the NavLabs".) However, we recognize that there were/are no NavLab requirement for payback let alone mention of working for a NavLab as a career option upon graduation, which only supports our argument to make such requirements mandatory in a UARC Plan and to actively recruit UARC grads.

Recommendations

To acquire top STEM PhD, MS, and BS students the Navy needs to support the UARCs in two different ways:

Provide the UARCs with scholarship / internship funds to engage X undergrad students, X graduate students, and X postdocs per year and per UARC: Hawaii, UW, Penn State, Johns Hopkins, U Texas. These students would receive full tuition and basic and/or applied research funding on finding solutions to important challenges facing today's Navy. The identified research challenges should be a specialty of and an area of each UARC's strategic expansion goals.

Continue to issue BAAs that allow PIs at the UARCs to acquire grant and/or contract funds for undergrads, grads, and postdocs to work on finding solutions to important problems facing today's Navy. A stipulation of this funding should require that part of their training, e.g., three months, should be conducted at a NavLab of the student's choice. Provide financial incentives to PIs to participate.

Preliminary UARC Plan Implementation:

- UARC select one area of strategic expansion for each undergraduate, graduate, and postdoc

- UARC identify Navy application / end goal for each strategic area

- UARC identify skill set to achieve end goal

- UARC identify degree(s), career path, and coarse work to achieve end goal

- UARC identify internal lab advisor and university advisor

- ONR set up guidelines for a stringent scholarship / internship program for UARCs to follow under new ONR funding; guidelines include a **contract** for student signature about working at a NavLab upon graduation

- UARC set up internal guidelines for tasks needing completion for student to fully comprehend the Navy application and the problem that needs to be addressed if not solved

REPORT DOCUMENTATION PAGE

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE June 2009	3. REPORT TYPE AND DATES COVERED Technical Report

4. TITLE AND SUBTITLE

Solving the Shortage of STEM Personnel in Navy Laboratories: Strategic Plan for Navy Investments in STEM Education Targeted at the "Navy After Next"

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13. ABSTRACT *(Maximum 200 words)*

The Navy Laboratory system (NavLabs) has a serious and growing problem replacing its tens of thousands of civilian STEM employees (Science, Technology, Engineering and Math: bachelors, masters, and PhDs). This report examines the Navy's STEM educational efforts and how they bear on the shortage of STEM personnel in the Nav-Labs, and develops a Preliminary Strategic Plan to address the problem.

In line with Navy practice of long-term planning for difficult logistical problems, this Preliminary Strategic Plan addresses the specific need: "More employee-years of civilian STEM workers at NavLabs." The plan consists of 33+ specific recommendations. Each is straightforward, and leverages aspects of existing programs where possible. Some are recommendations for new programs or approaches. Collectively they form a coherent plan. A more detailed implementation plan can be developed quickly if the Navy adopts the Preliminary Strategic Plan.

14. SUBJECT TERMS

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